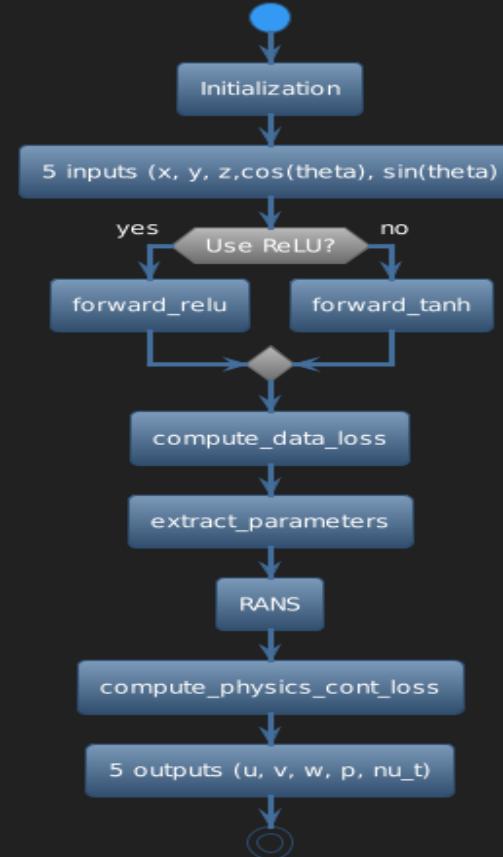
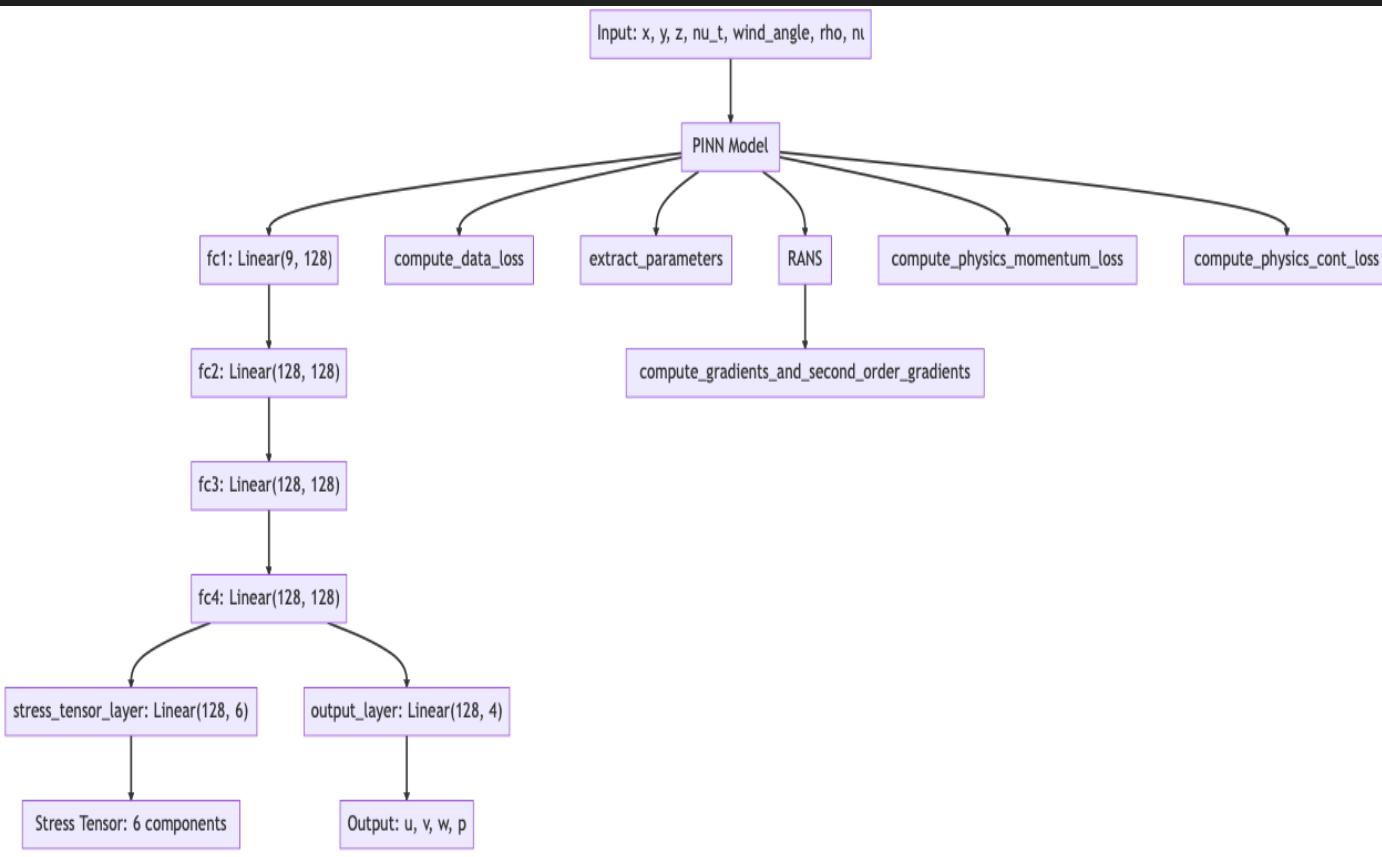


PM003 – 30 October 2022

Update on PINNs

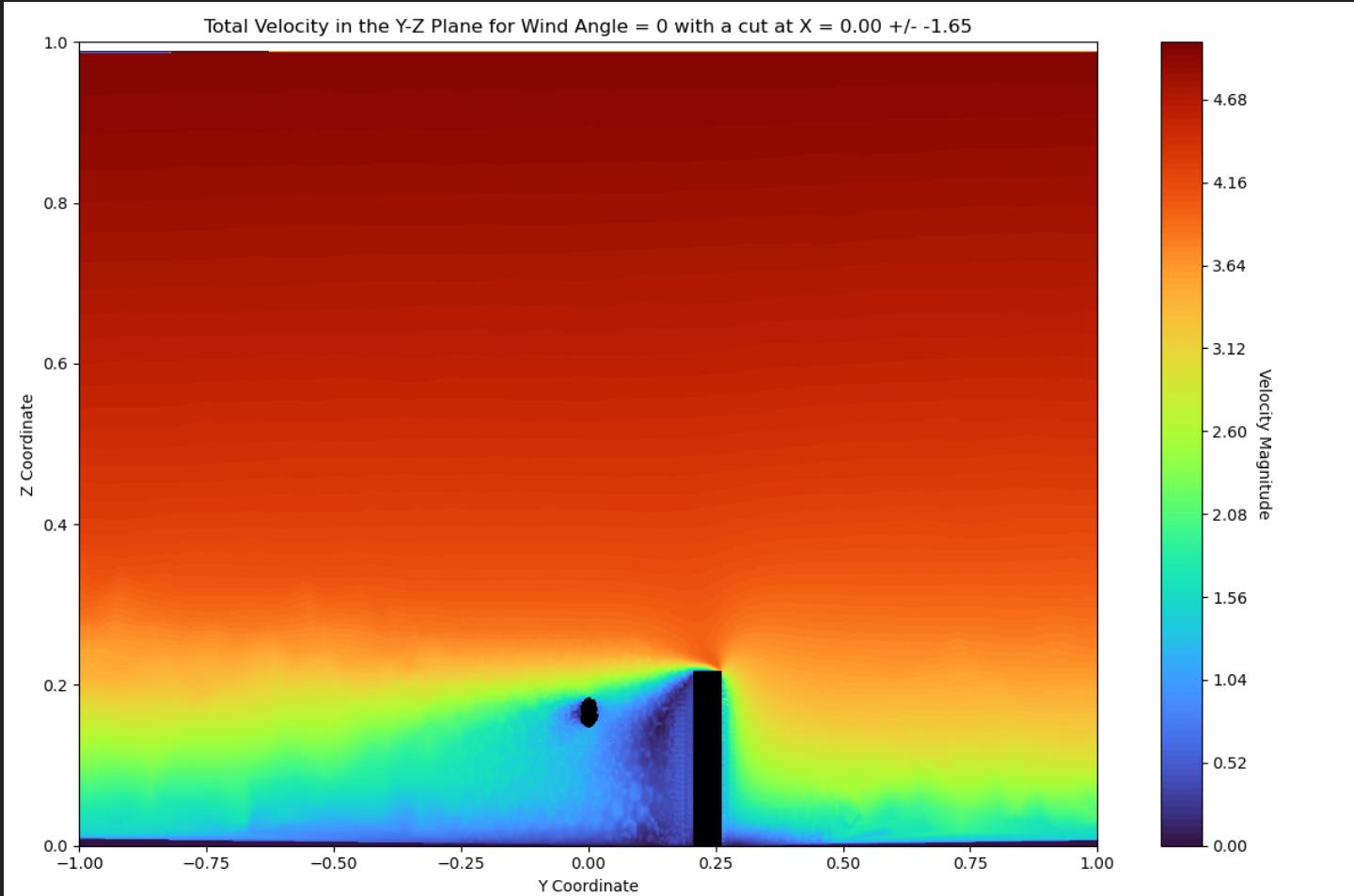
Application to Urban Wind Field Dispersion Studies

Neural Network Architecture – Previous vs Updated

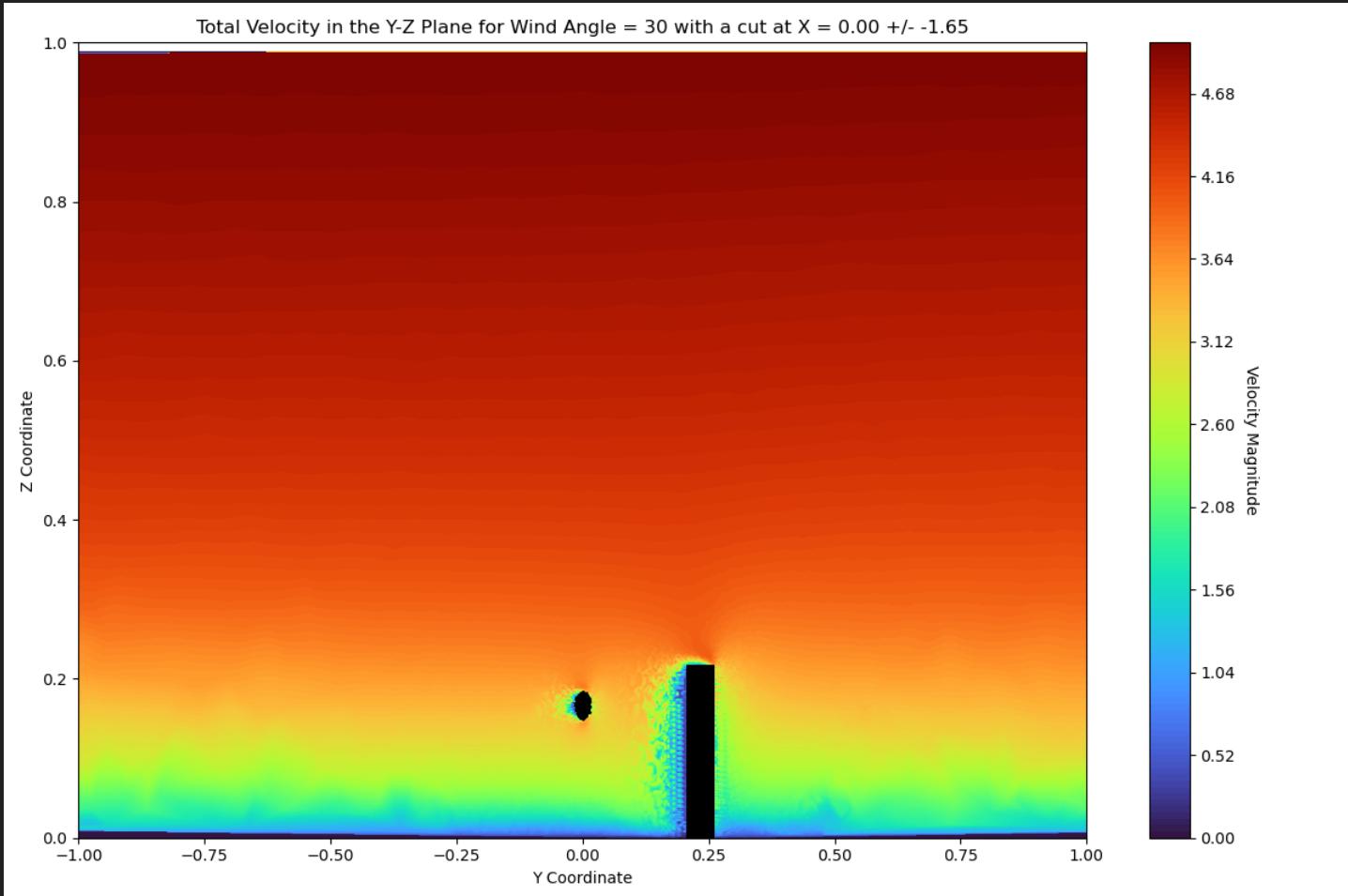


Pure Data Plots

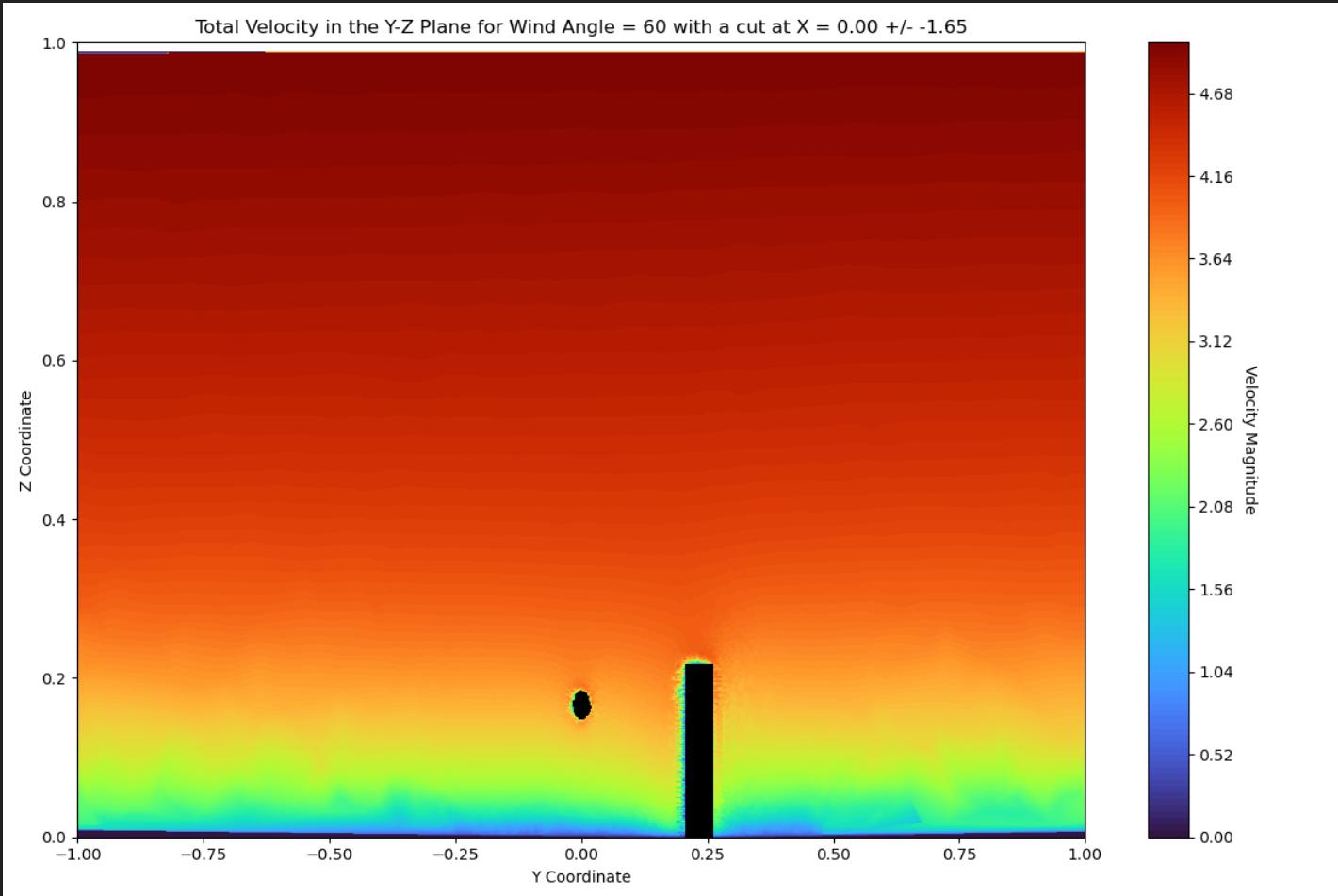
Data Plots – wind angle = 0



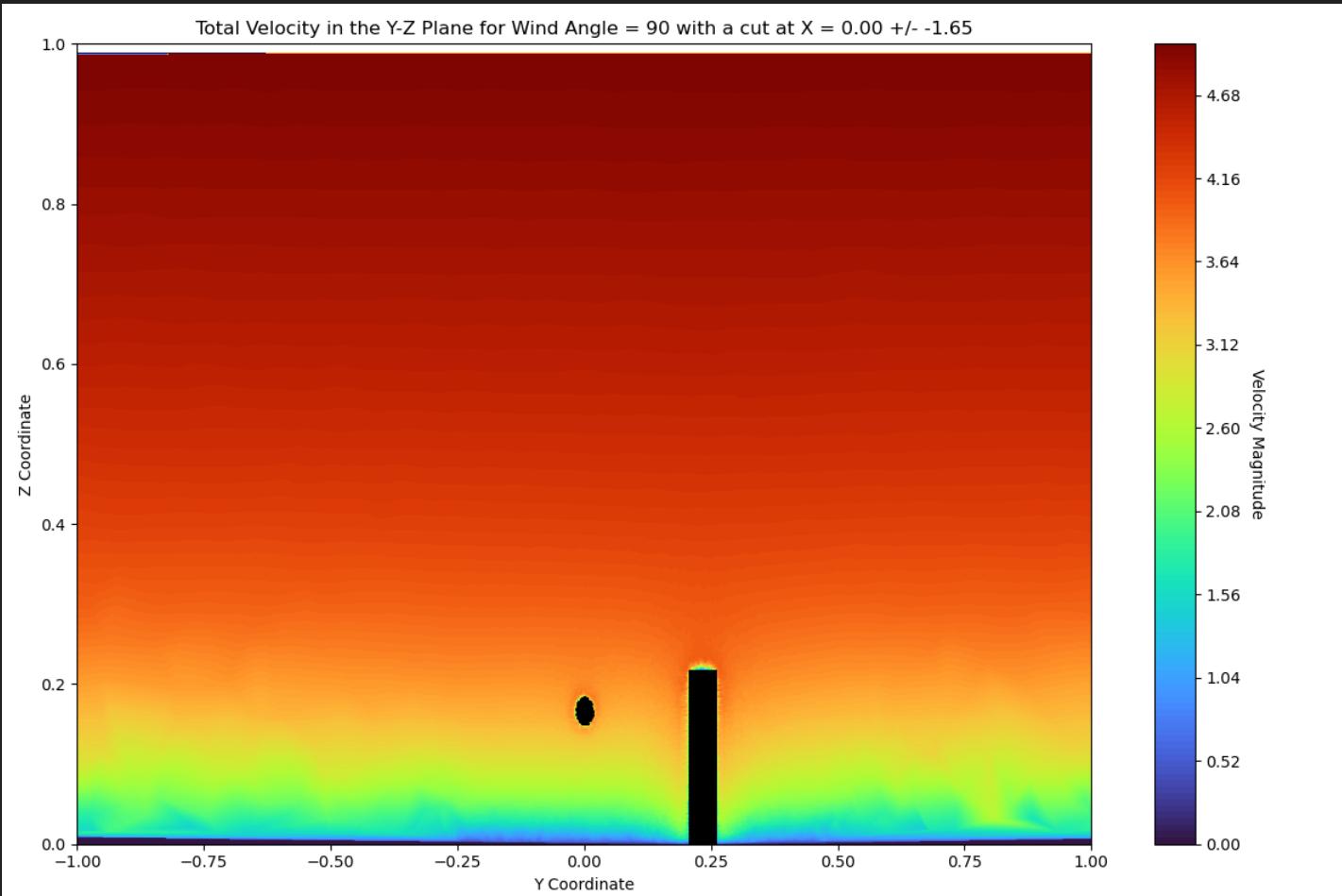
Data Plots – wind angle = 30



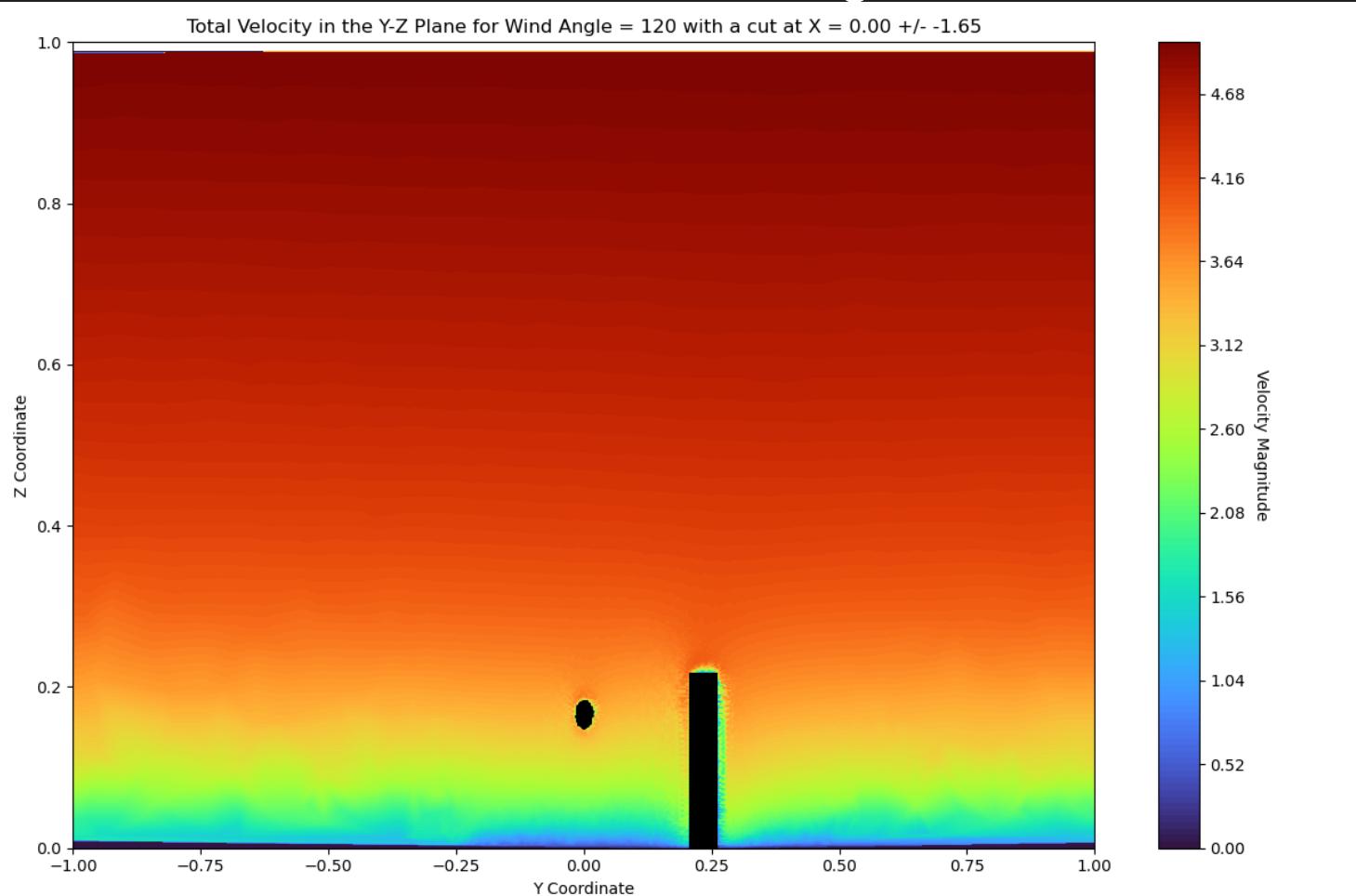
Data Plots – wind angle = 60



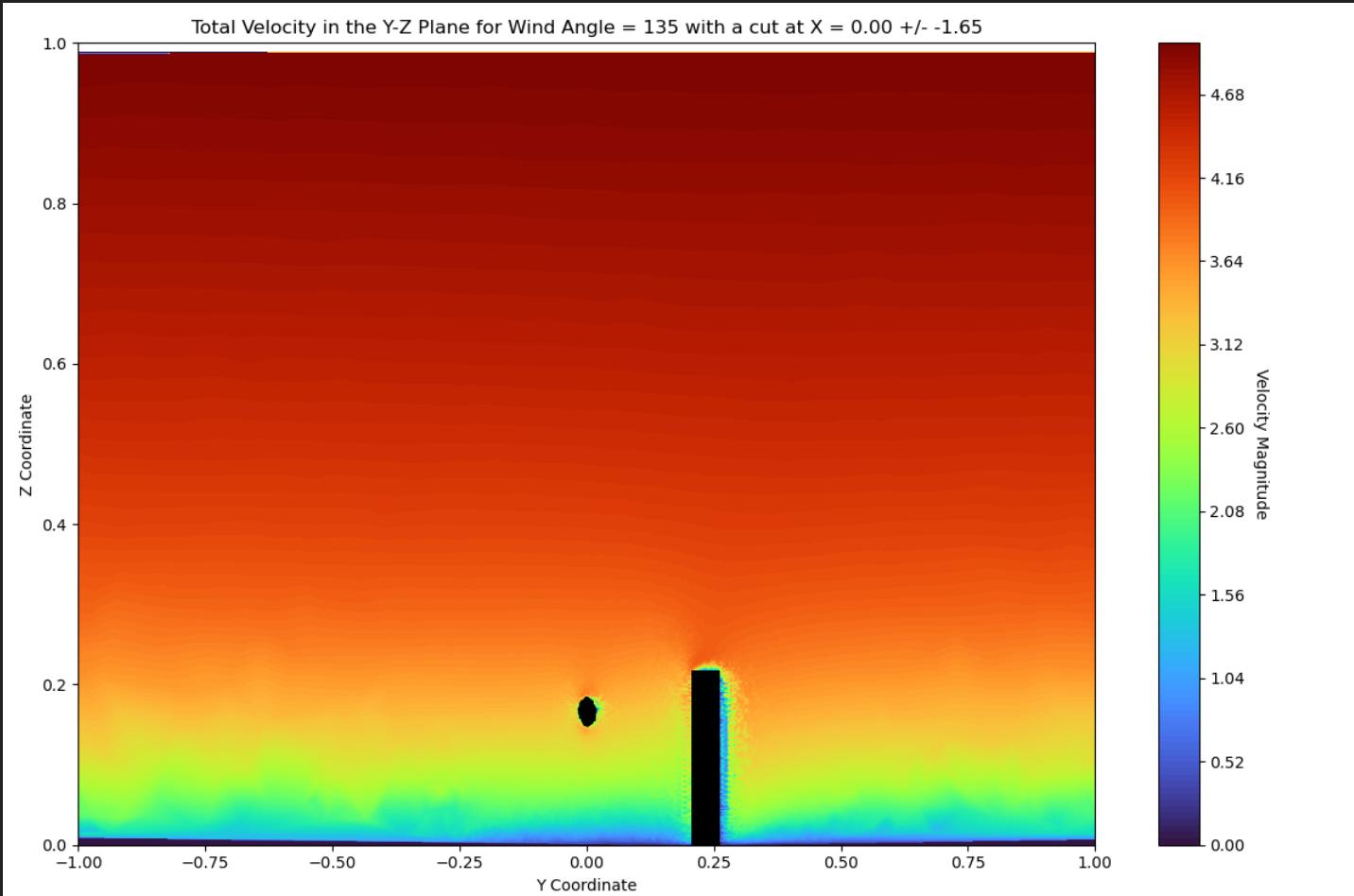
Data Plots – wind angle = 90



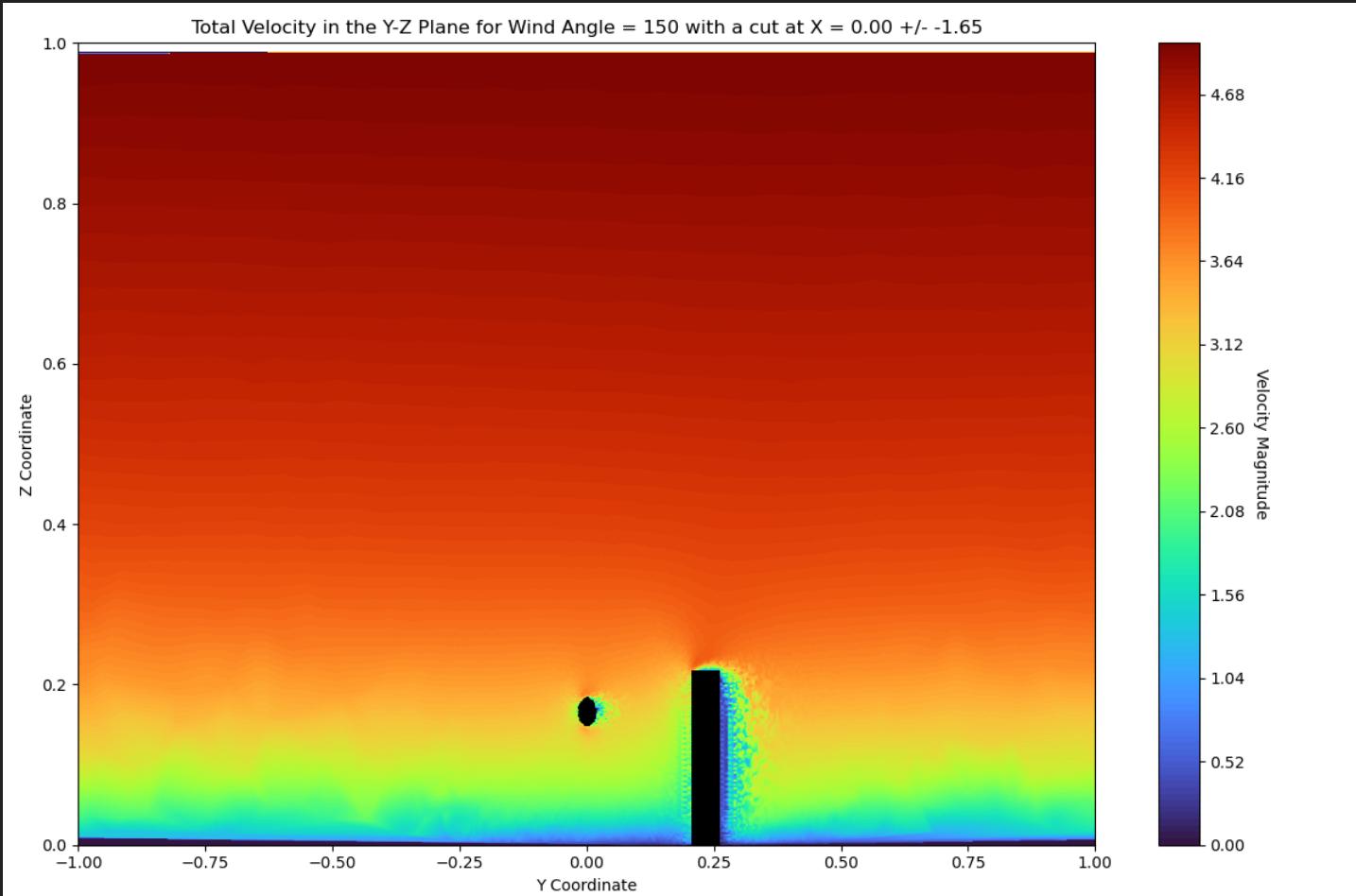
Data Plots – wind angle = 120



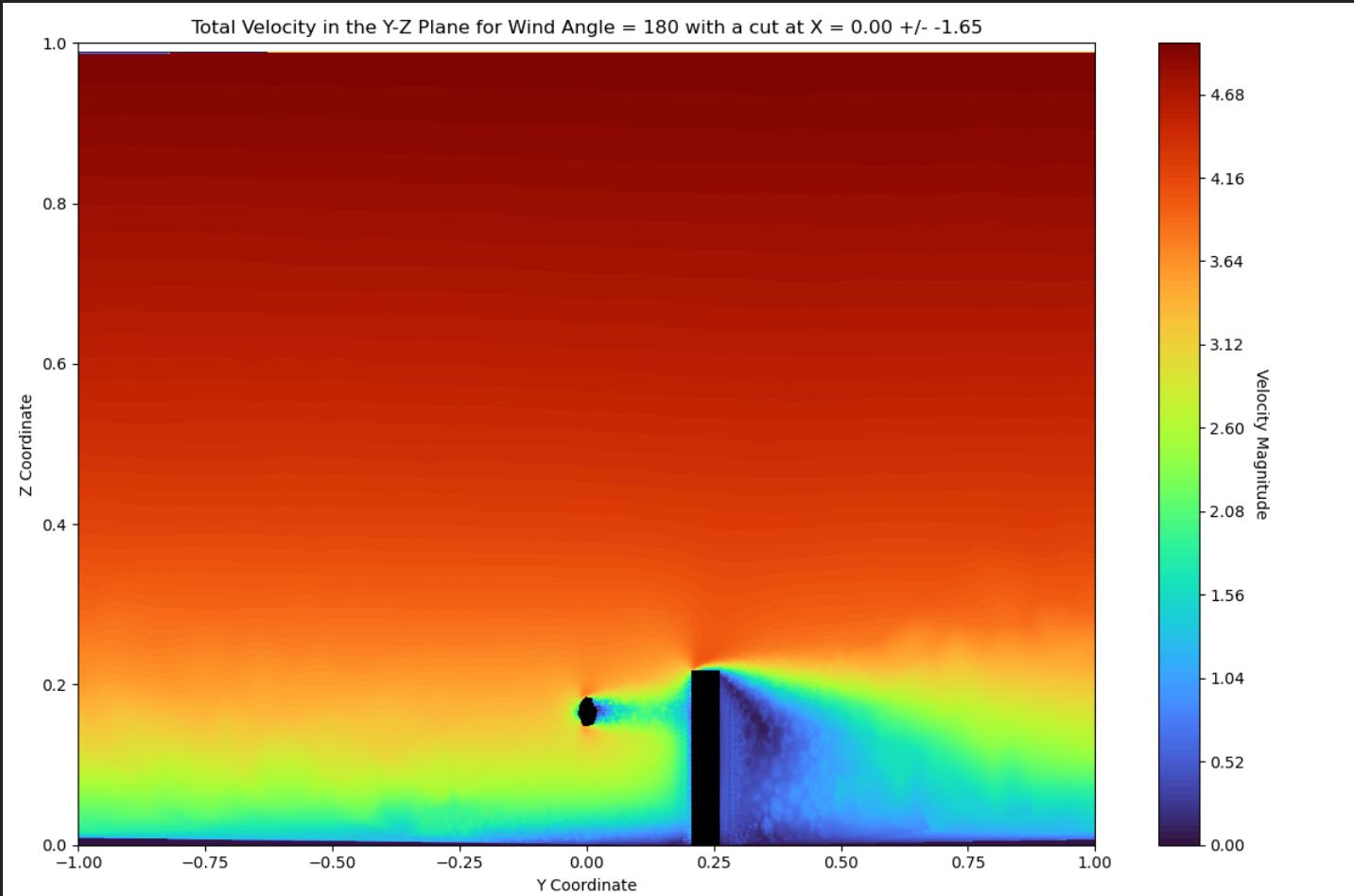
Data Plots – wind angle = 135



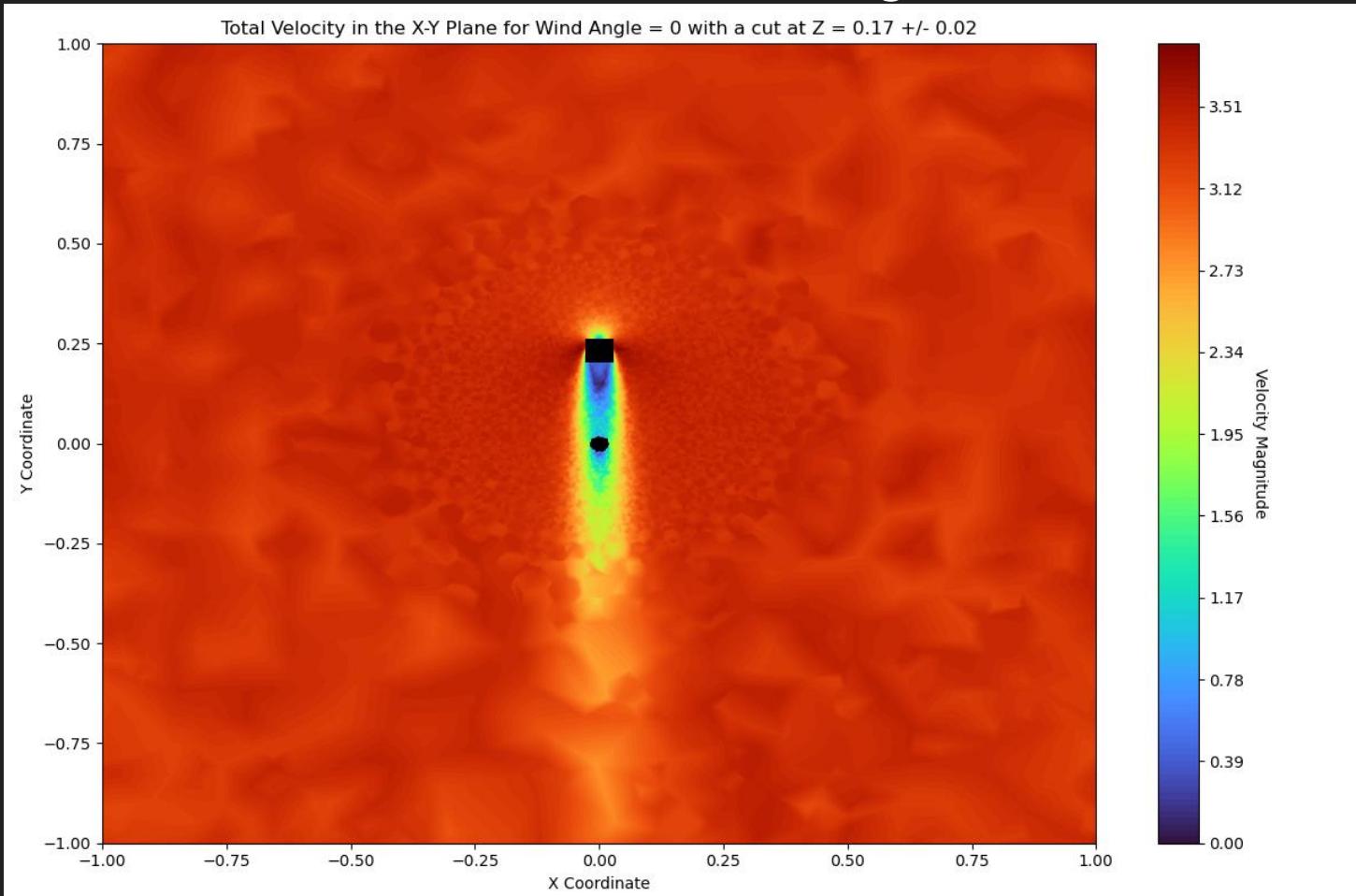
Data Plots – wind angle = 150



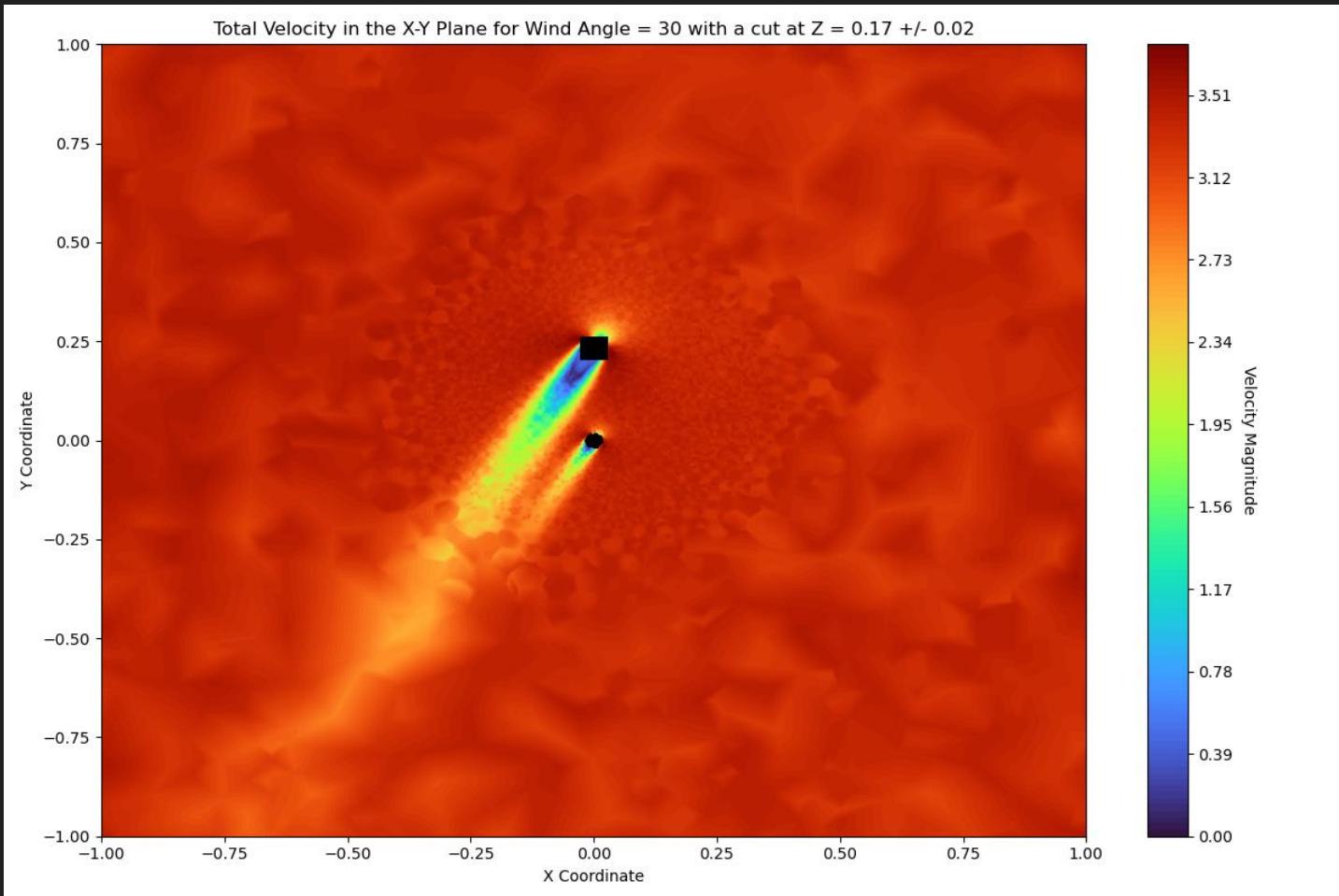
Data Plots – wind angle = 180



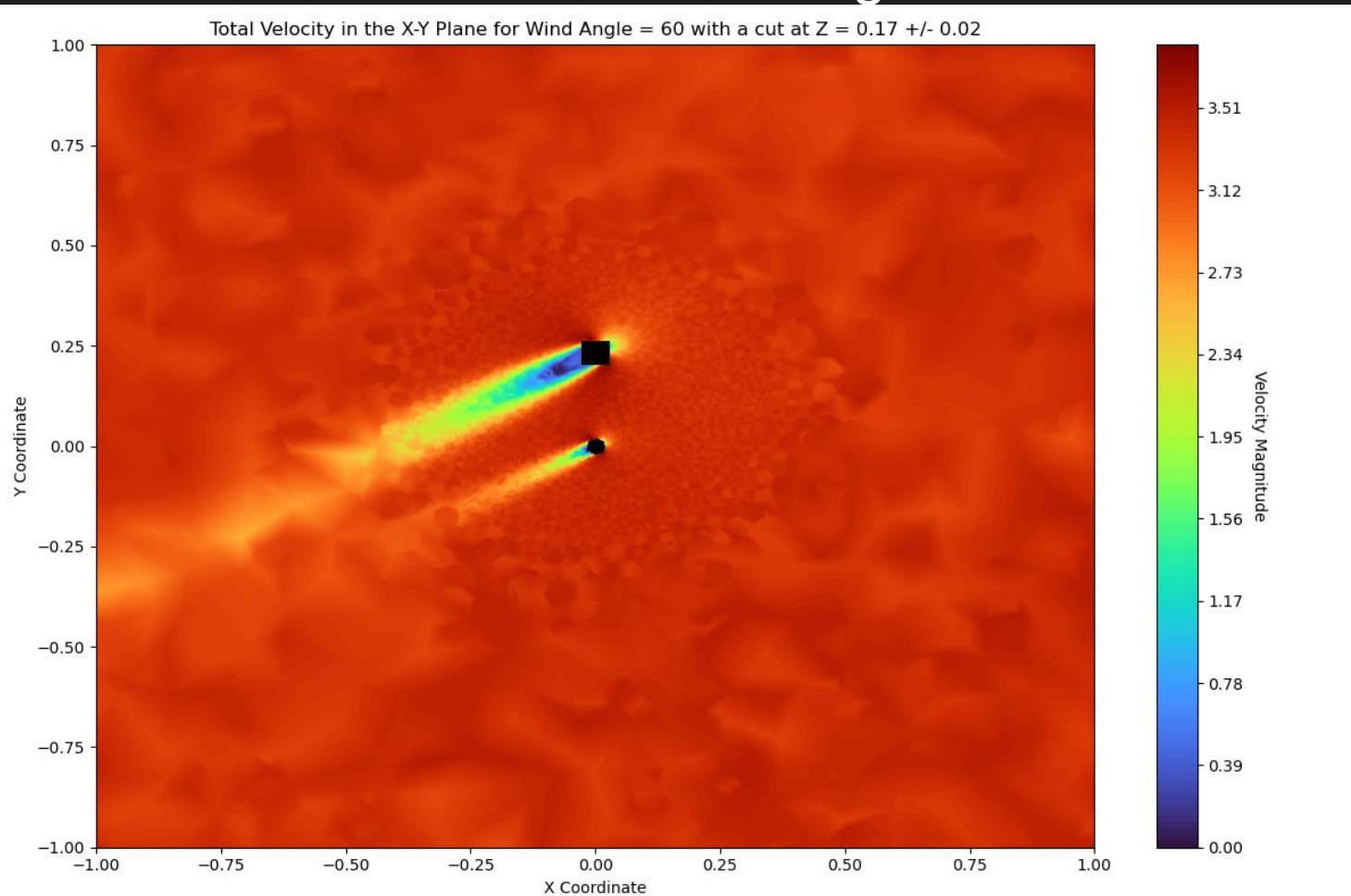
Data Plots – wind angle = 0



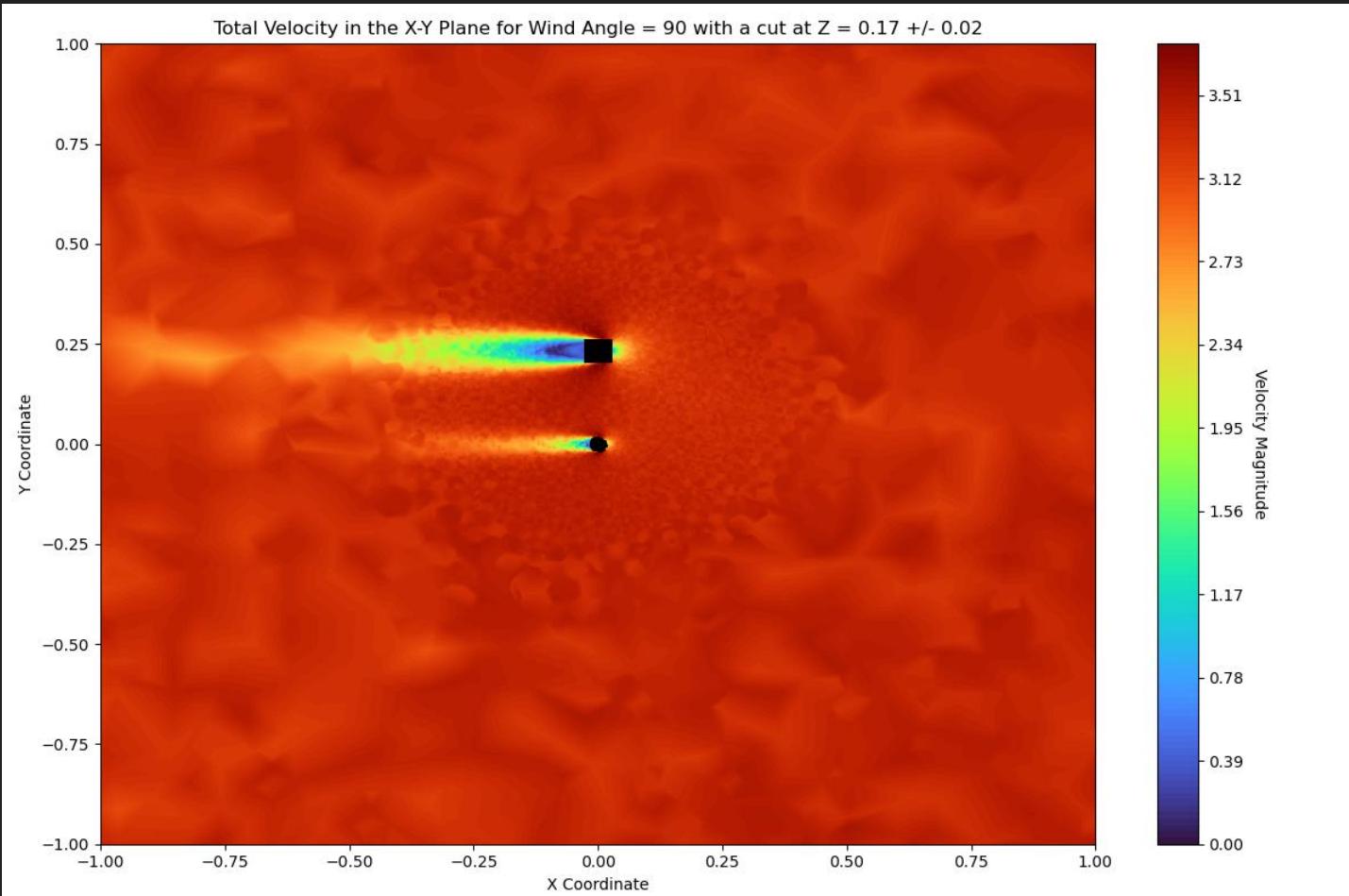
Data Plots – wind angle = 30



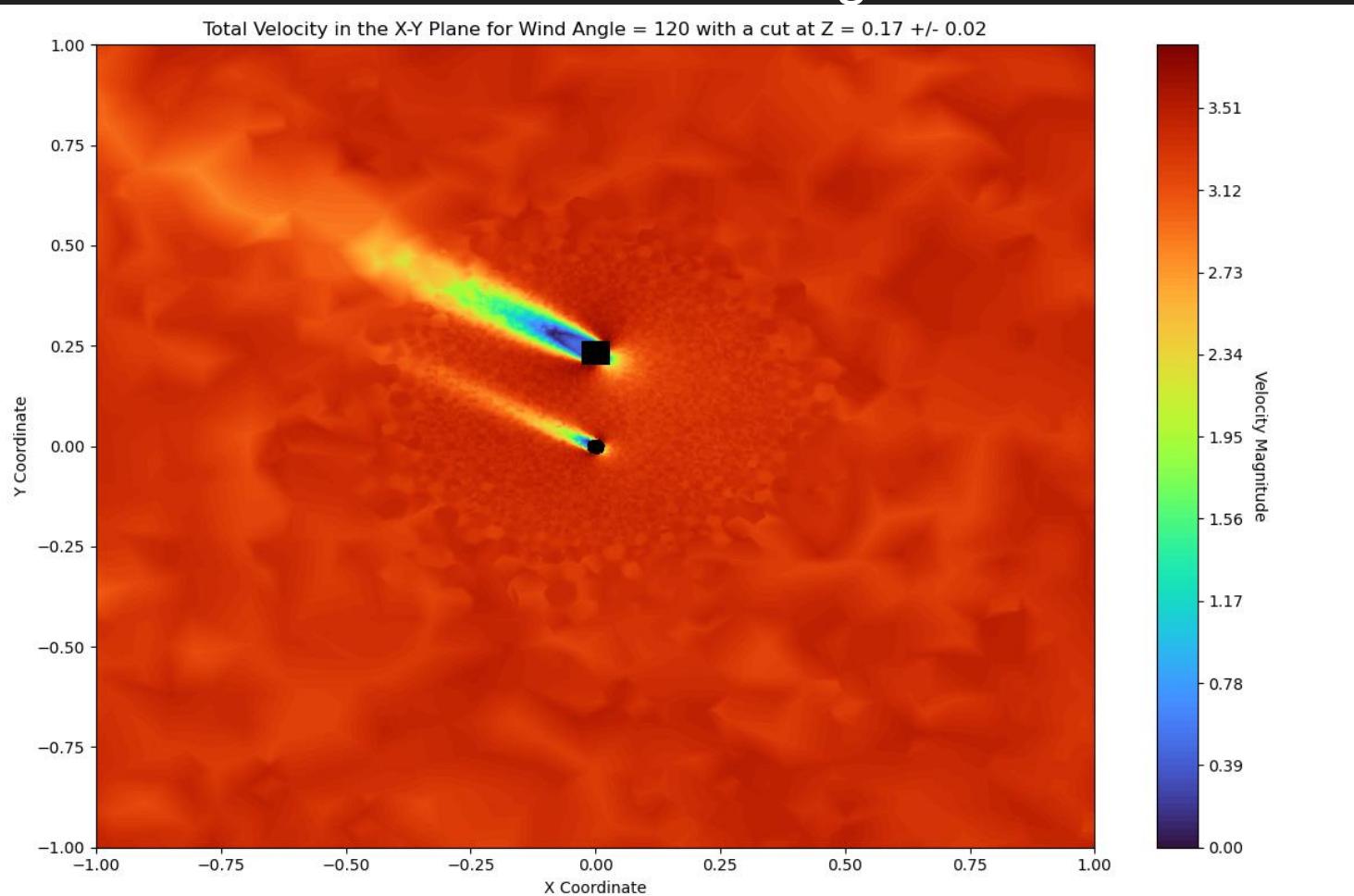
Data Plots – wind angle = 60



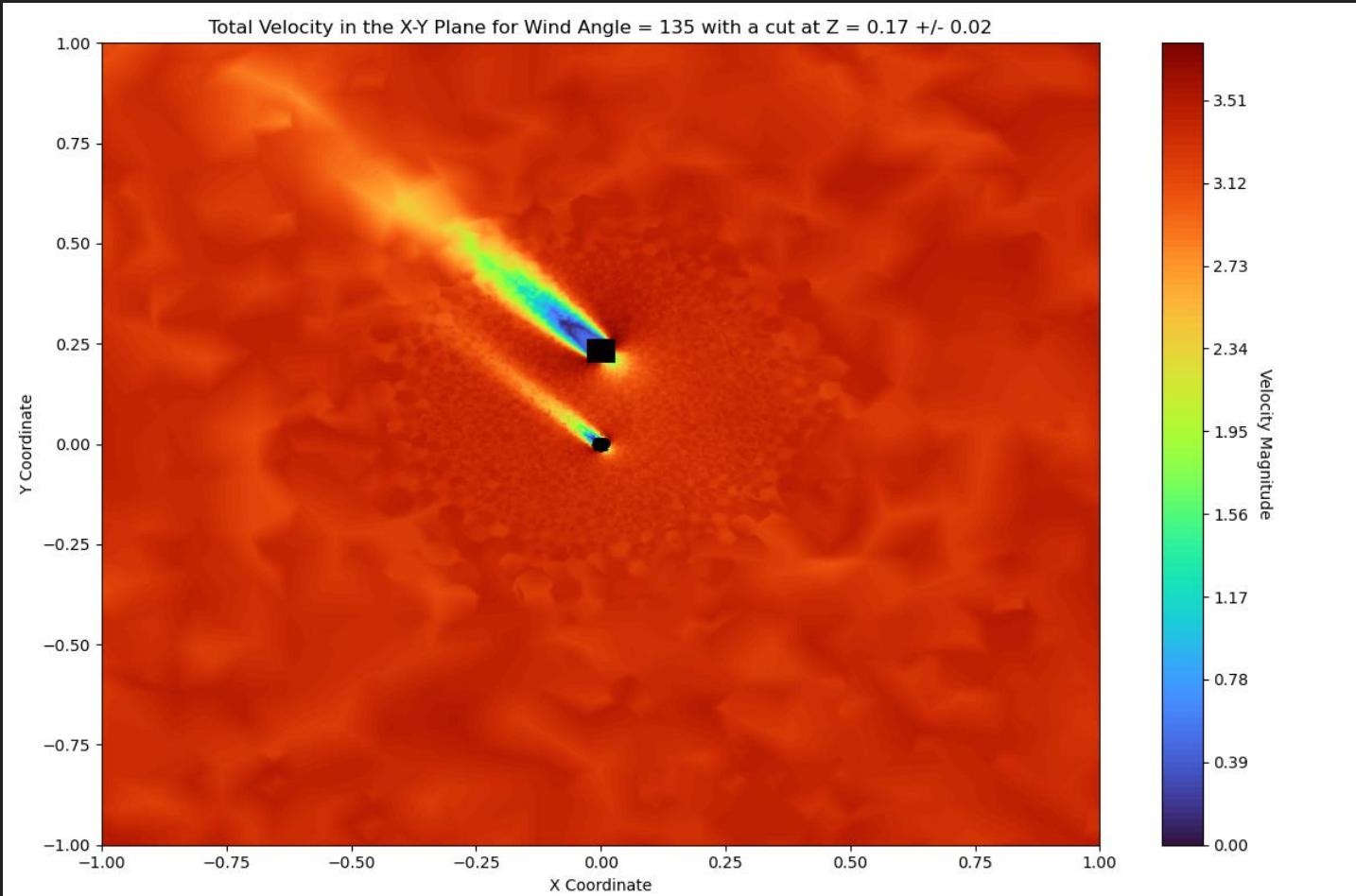
Data Plots – wind angle = 90



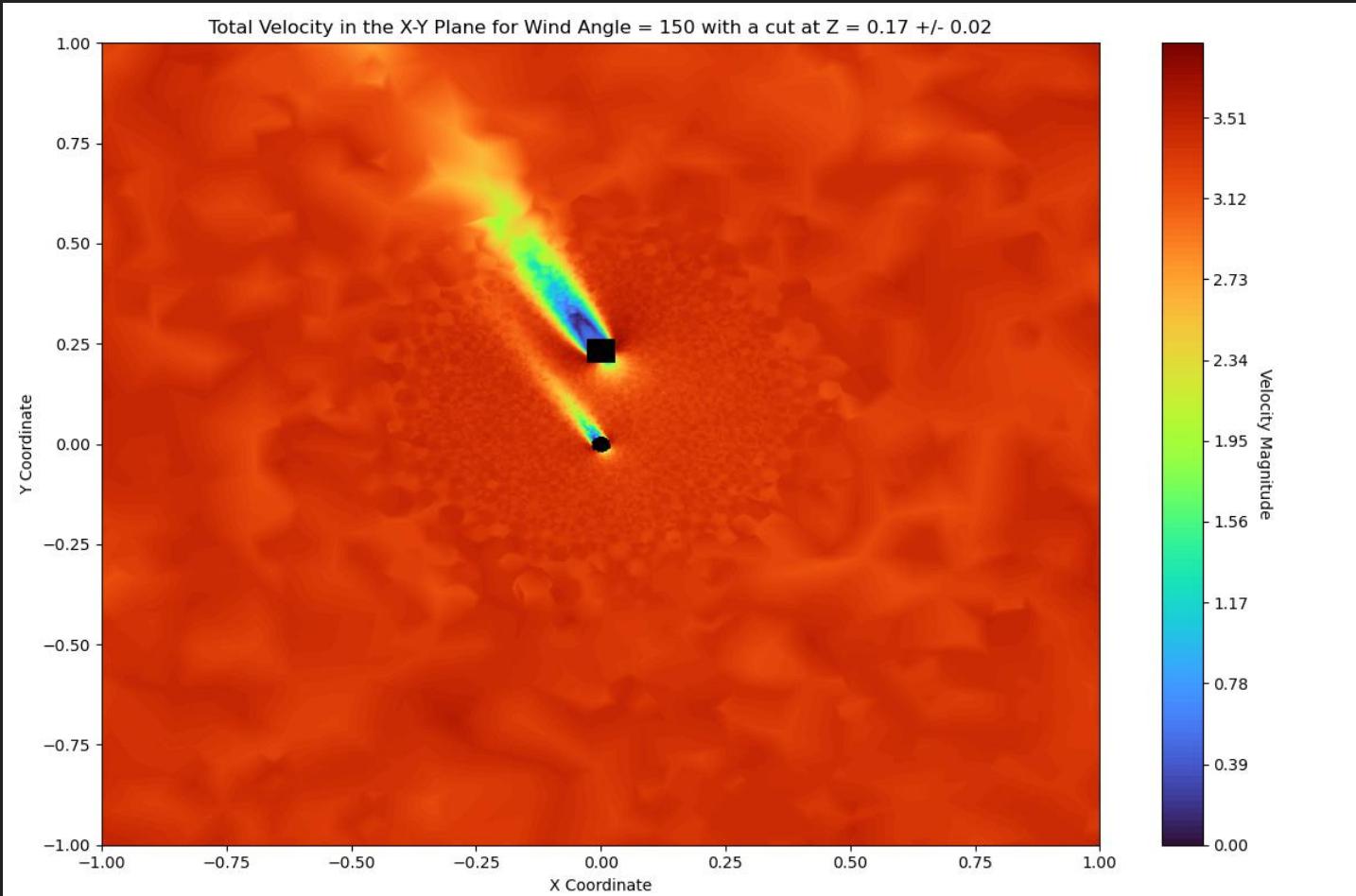
Data Plots – wind angle = 120



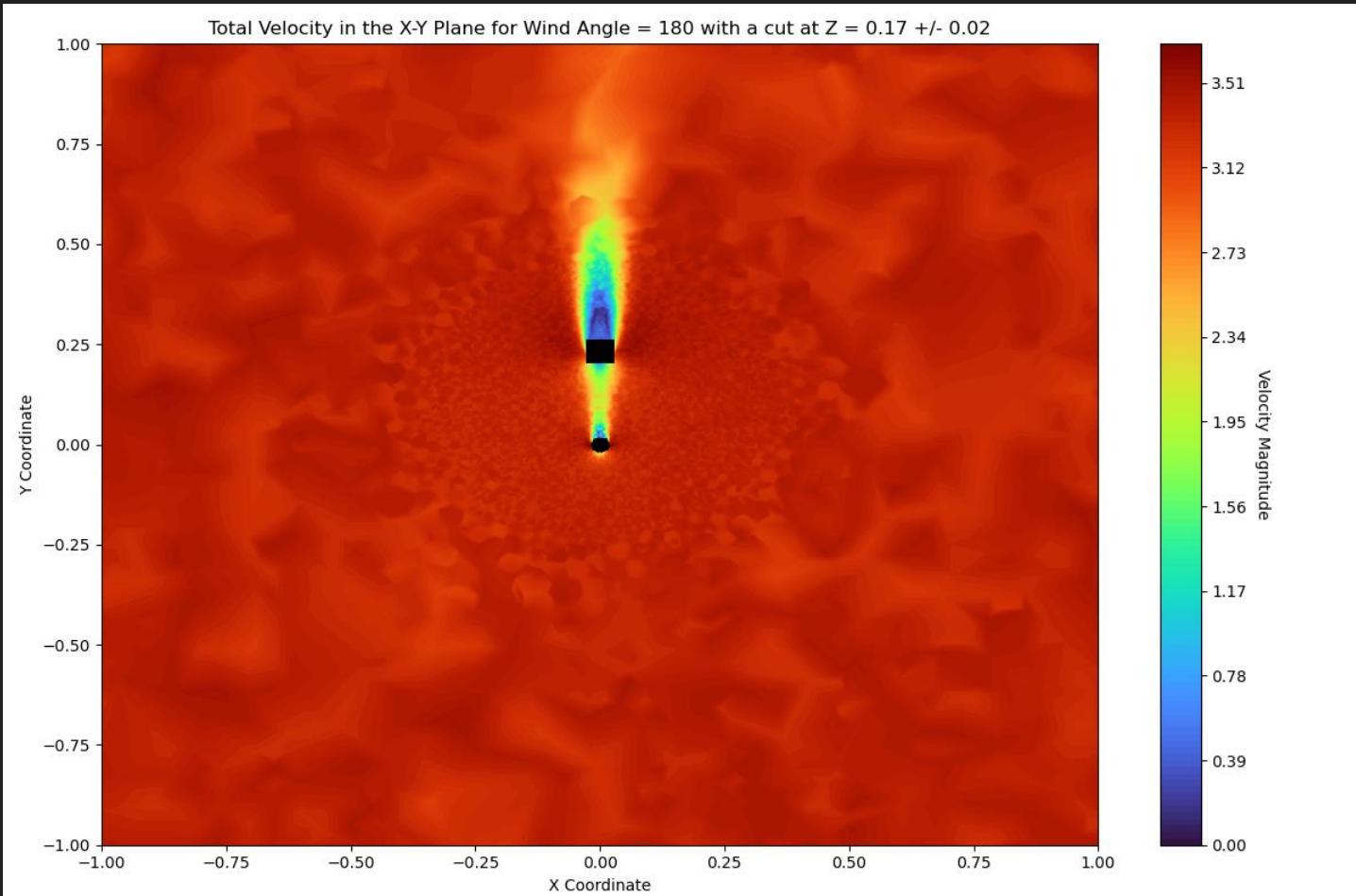
Data Plots – wind angle = 135



Data Plots – wind angle = 150



Data Plots – wind angle = 180



Progress so far - Data Loss + Cont Loss
(Adam Optimizer)

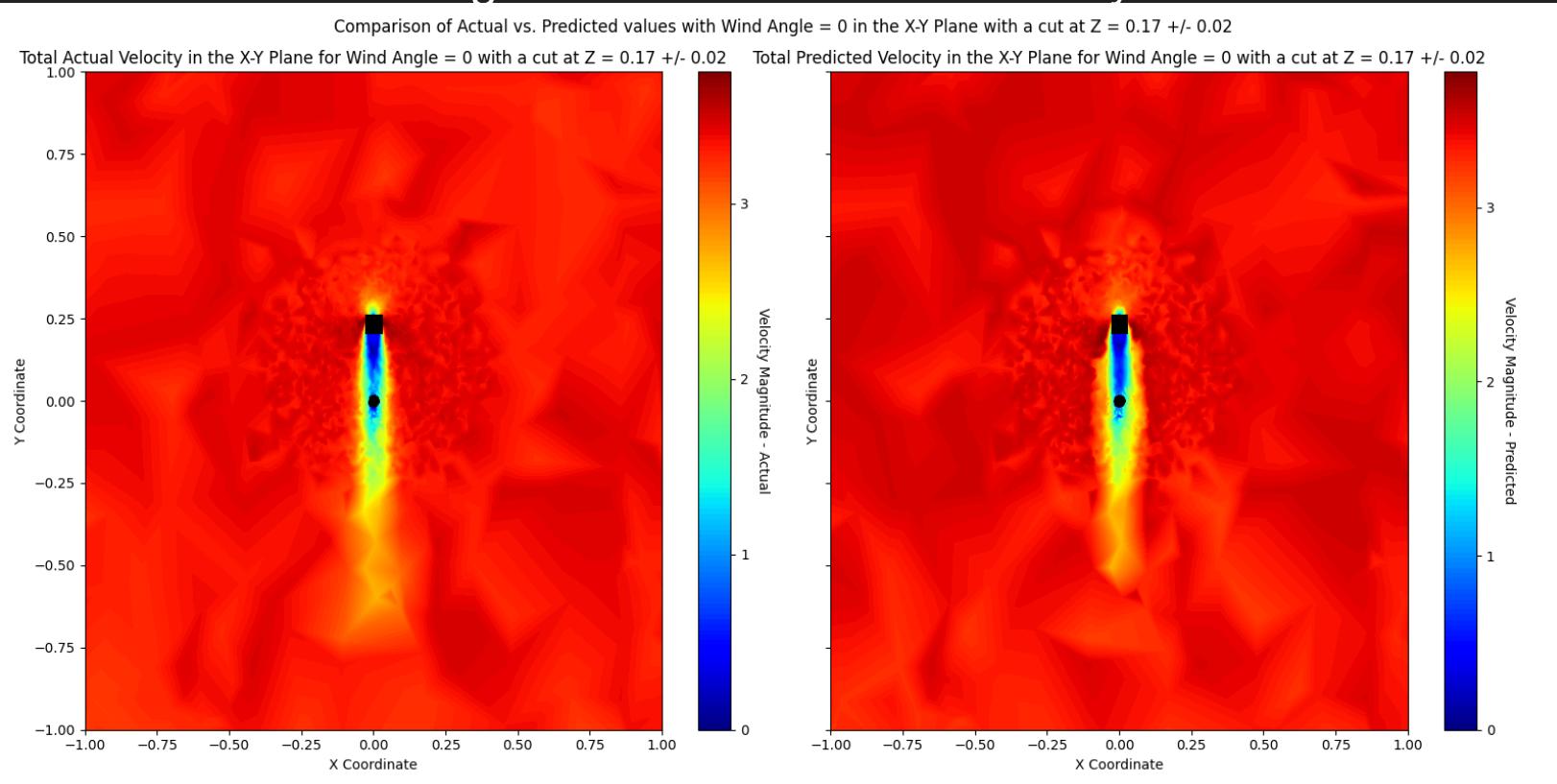
Threshold = 1E-5 (9120 Epochs, so far...),
GPU Laptop

Scripts v1 - TESTING

Progress so far - Data Loss + Cont Loss (Adam Optimizer)
Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop
Testing Results - Metrics

Variable	MSE	RMSE	MAE	R2
Pressure	0.03058529	0.1748865	0.08485891	0.99351423
Velocity:0	0.01834383	0.13543941	0.06264316	0.99091249
Velocity:1	0.03576996	0.18912948	0.09784344	0.99567361
Velocity:2	0.00020081	0.0141709	0.00805722	0.99350792

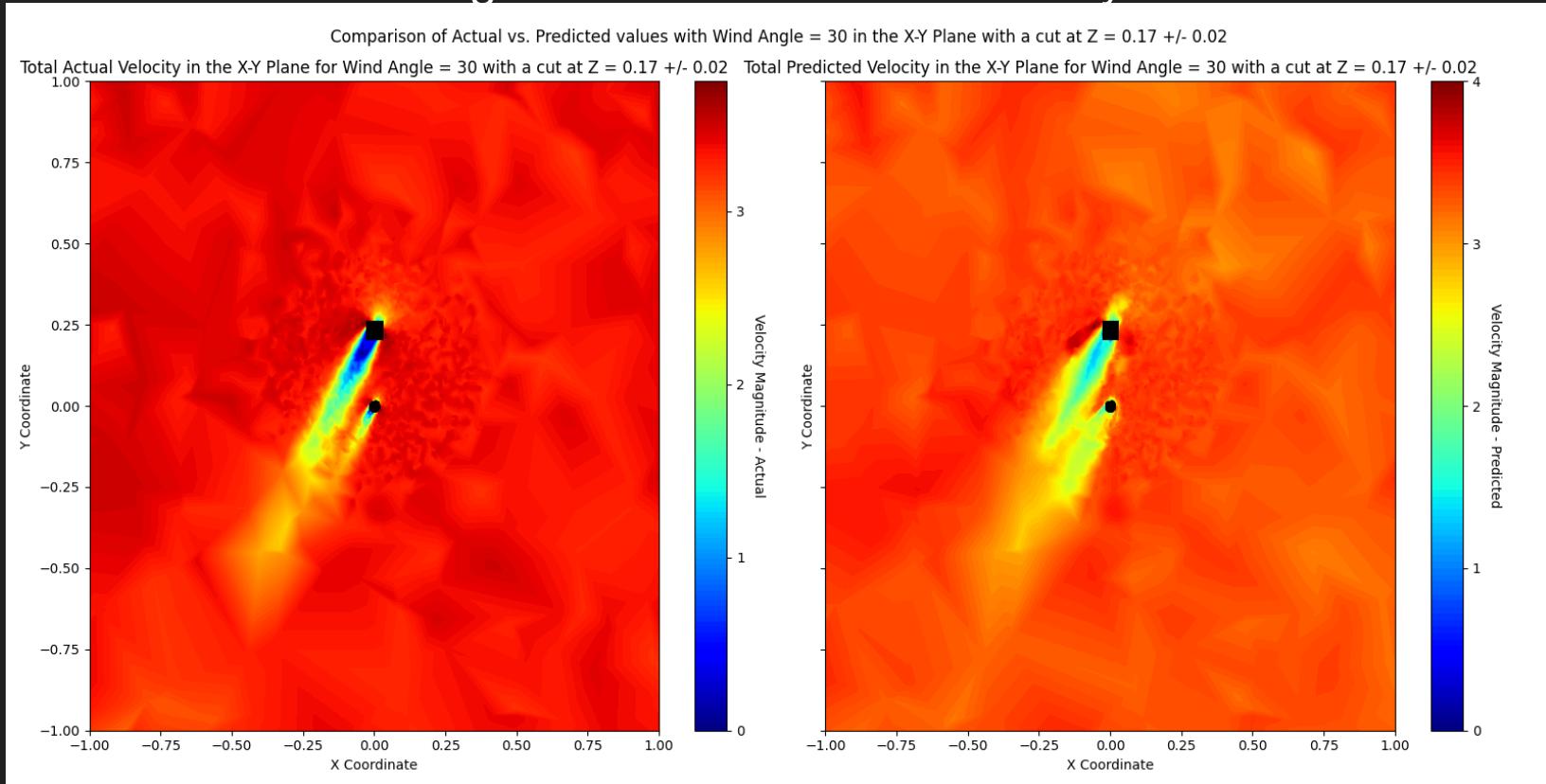
Progress so far - Data Loss + Cont Loss (Adam Optimizer) Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop Testing Results - X-Y Total Velocity Plot



Progress so far - Data Loss + Cont Loss (Adam Optimizer)

Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop

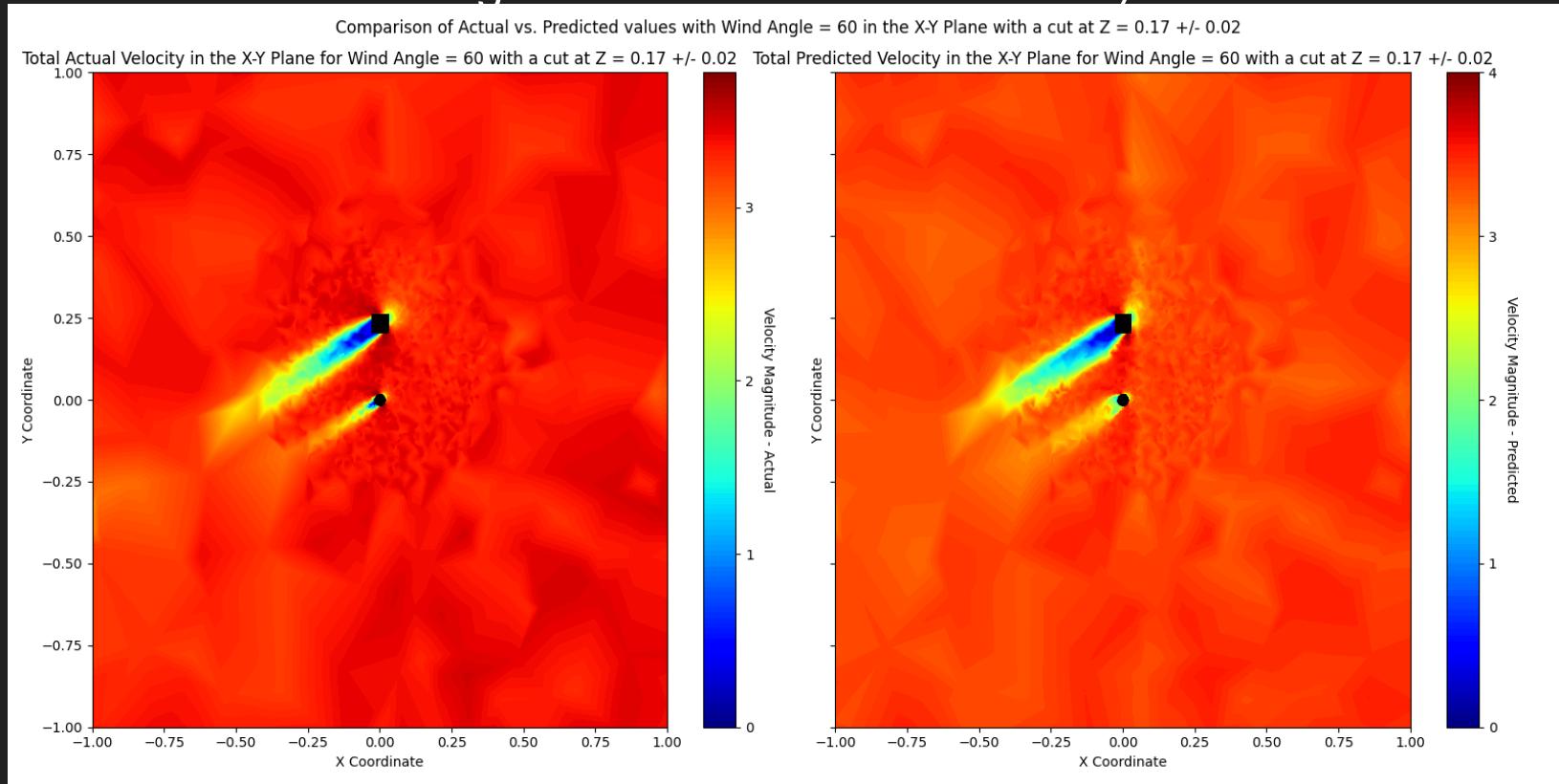
Testing Results - X-Y Total Velocity Plot



Progress so far - Data Loss + Cont Loss (Adam Optimizer)

Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop

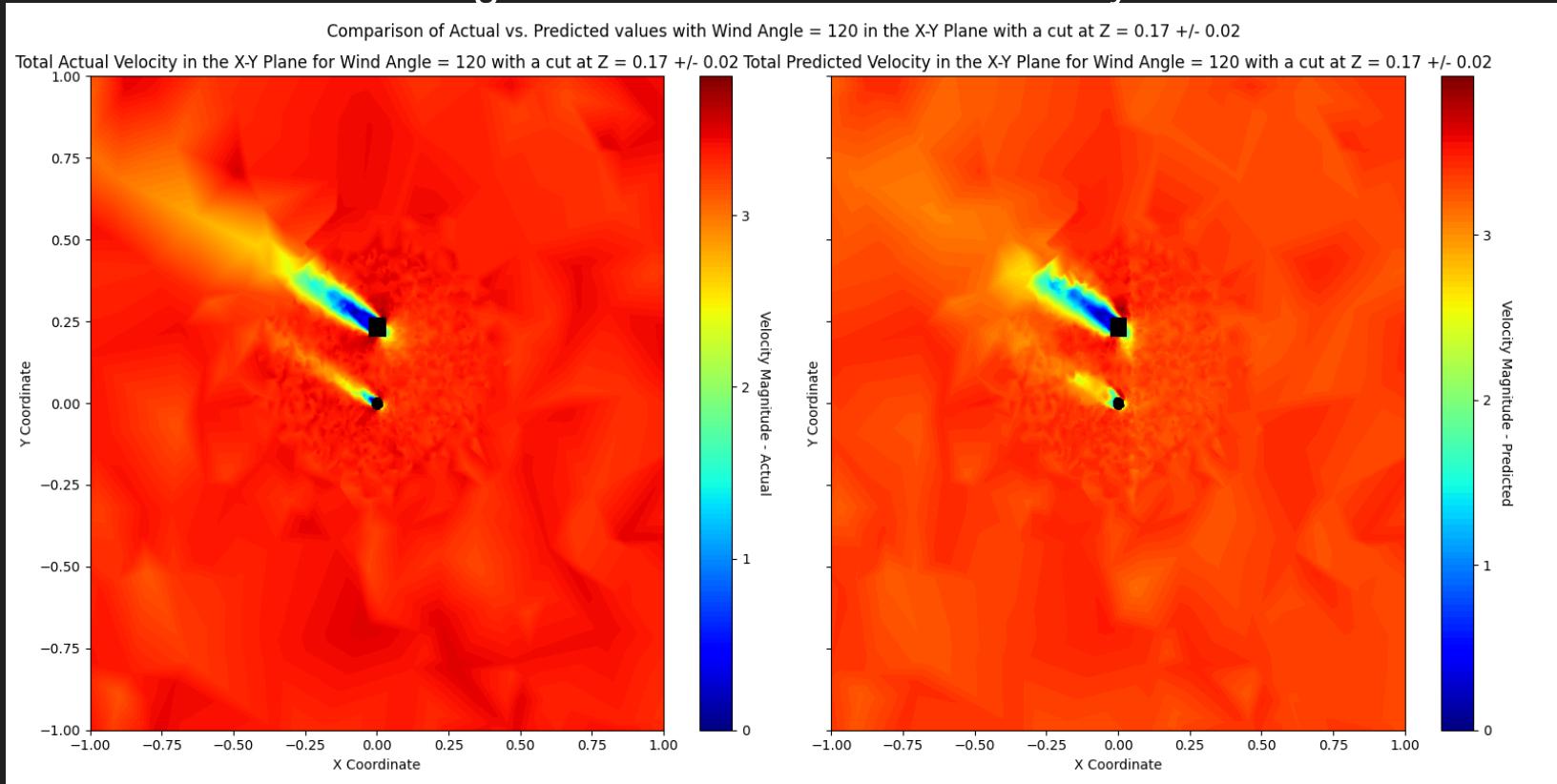
Testing Results - X-Y Total Velocity Plot



Progress so far - Data Loss + Cont Loss (Adam Optimizer)

Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop

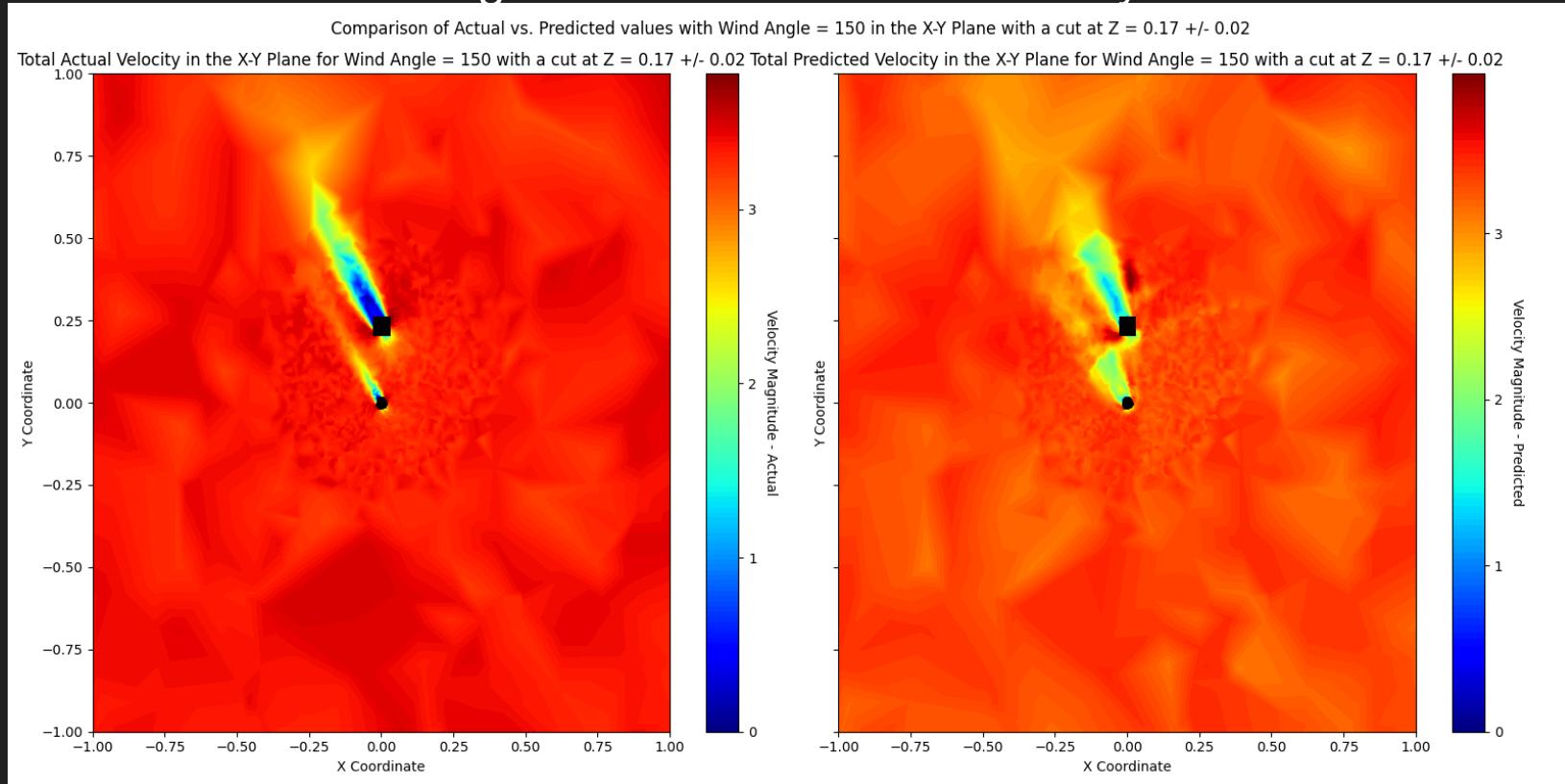
Testing Results - X-Y Total Velocity Plot



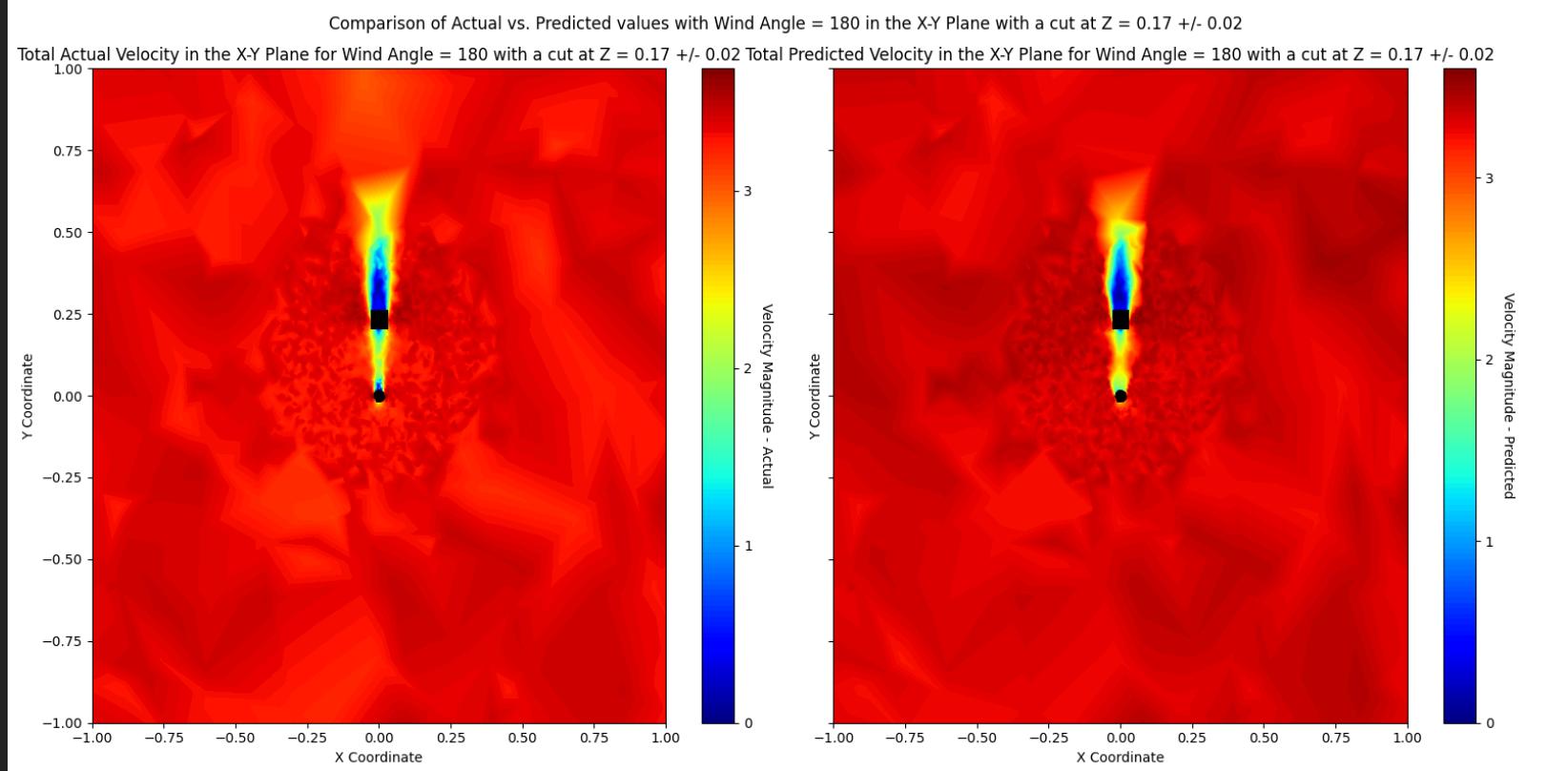
Progress so far - Data Loss + Cont Loss (Adam Optimizer)

Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop

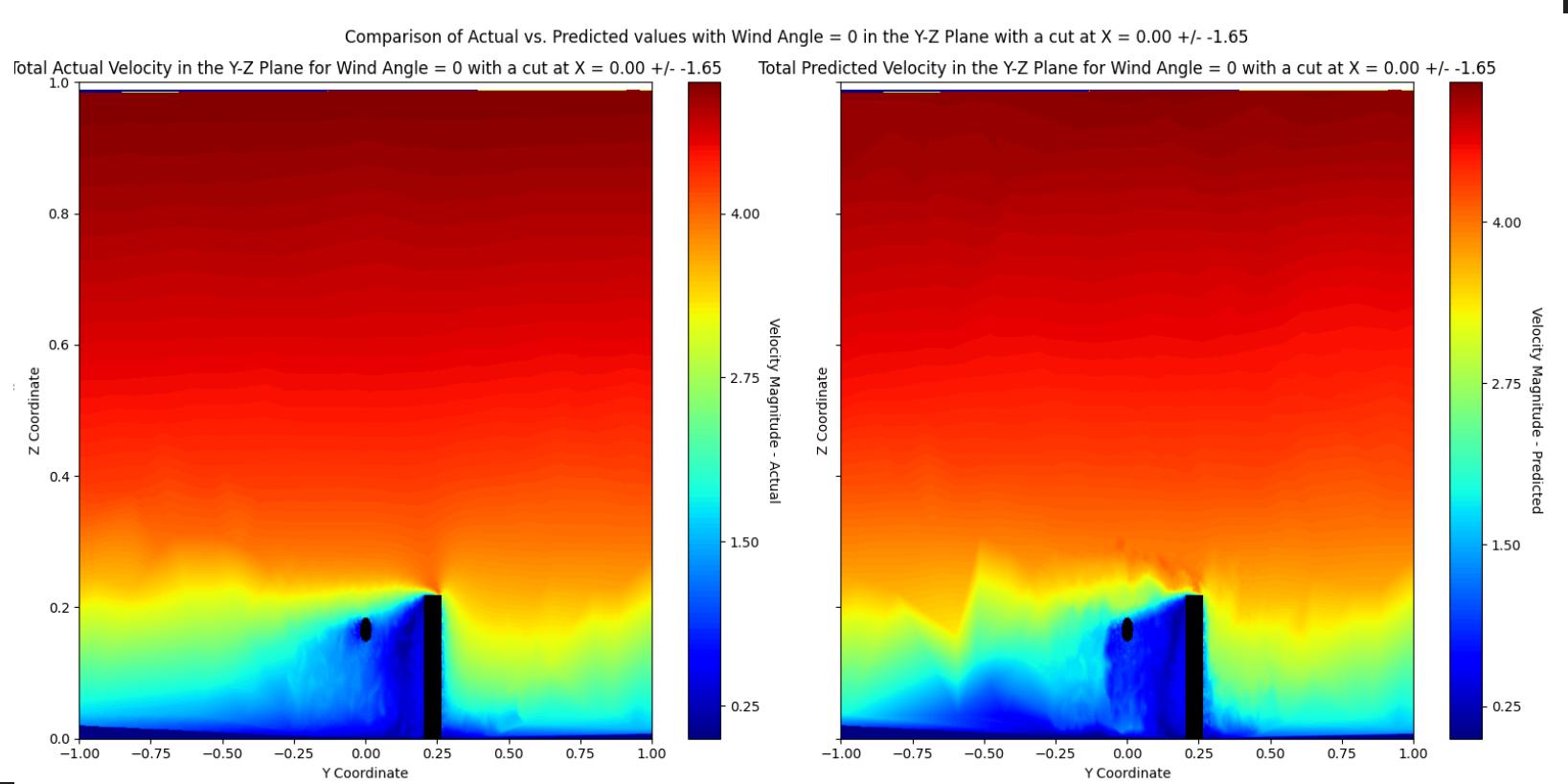
Testing Results - X-Y Total Velocity Plot



Progress so far - Data Loss + Cont Loss (Adam Optimizer) Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop Testing Results - X-Y Total Velocity Plot



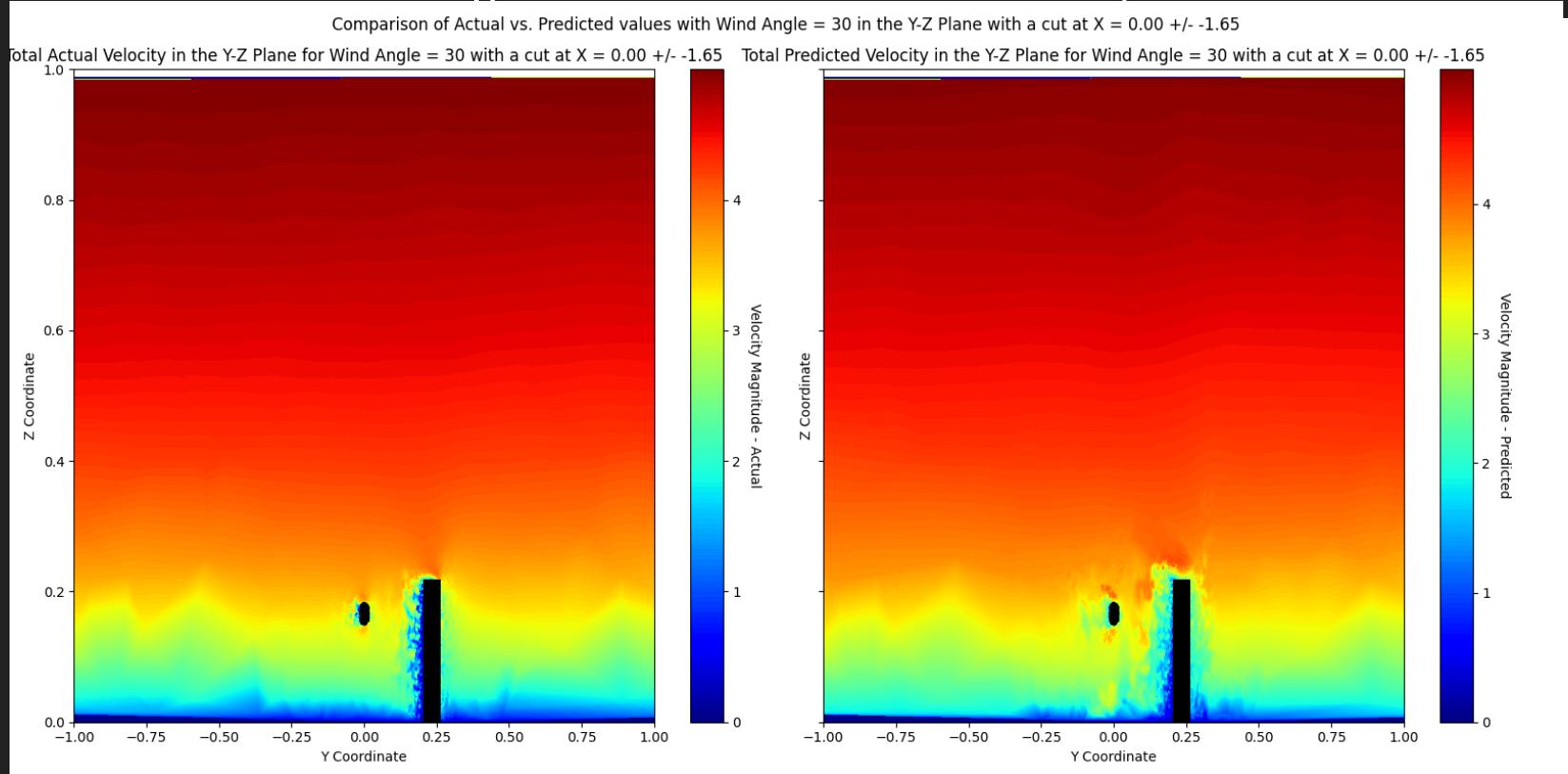
Progress so far - Data Loss + Cont Loss (Adam Optimizer) Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop Testing Results – Y-Z Total Velocity Plot



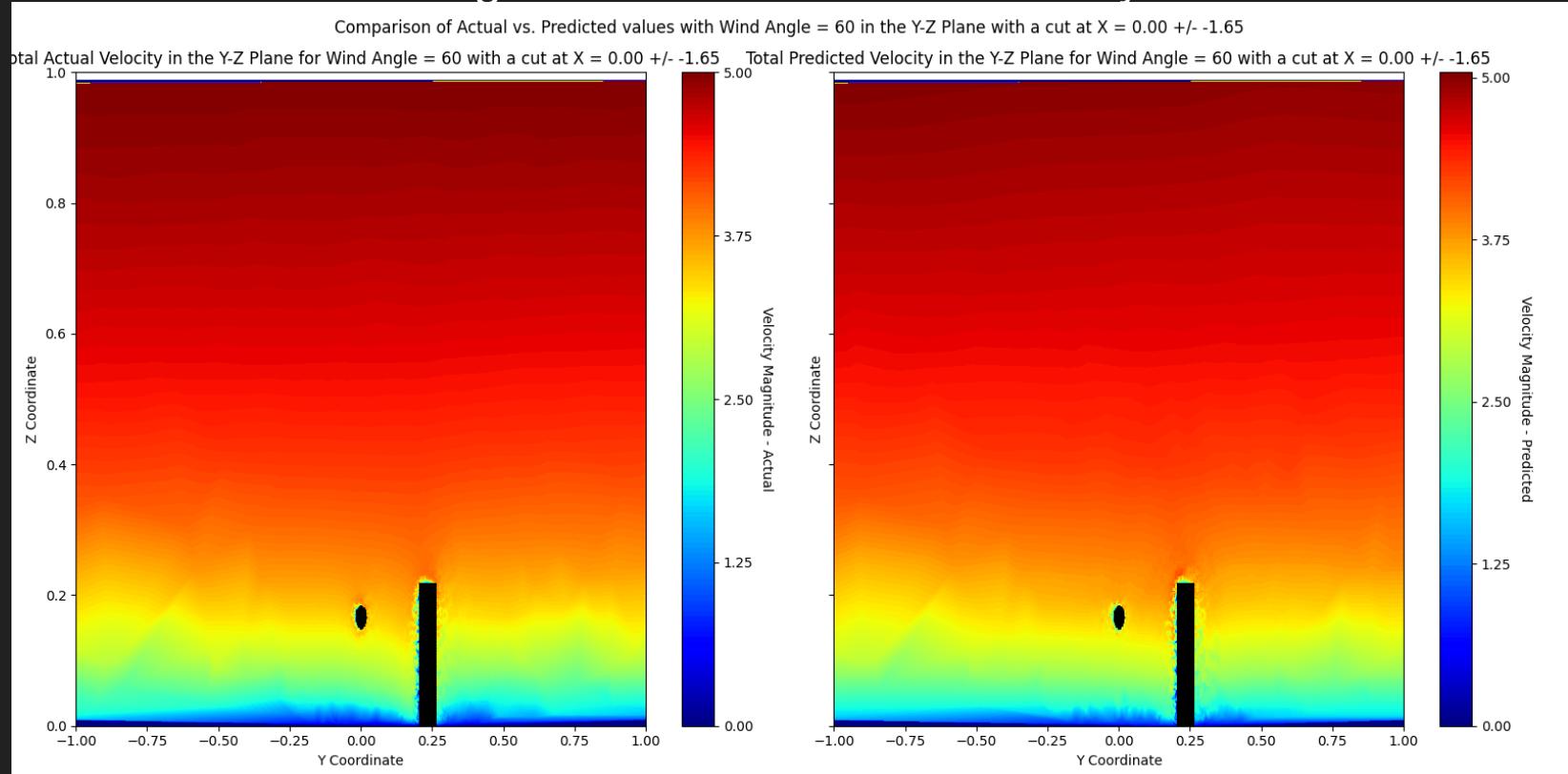
Progress so far - Data Loss + Cont Loss (Adam Optimizer)

Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop

Testing Results – Y-Z Total Velocity Plot



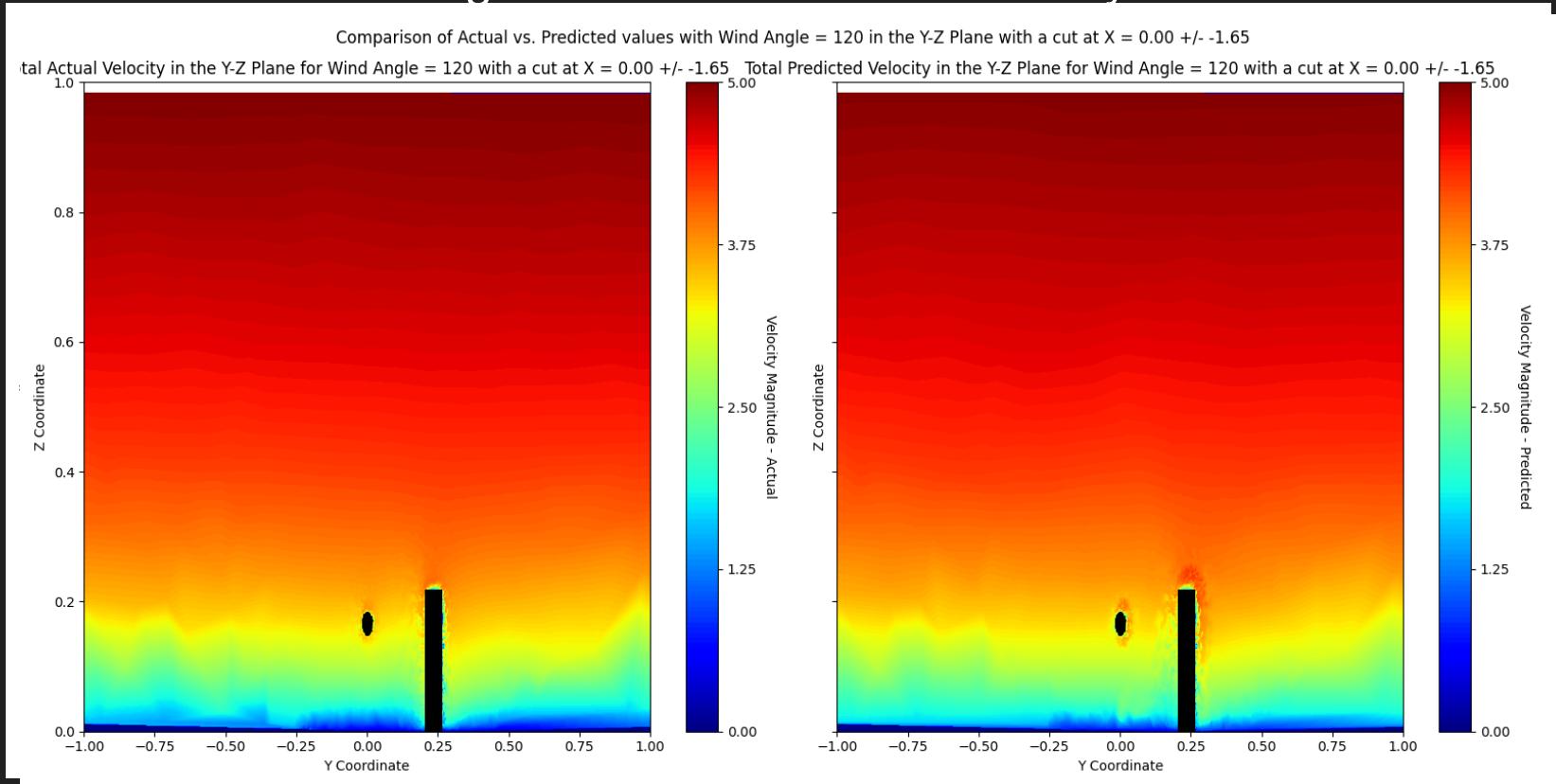
Progress so far - Data Loss + Cont Loss (Adam Optimizer) Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop Testing Results – Y-Z Total Velocity Plot



Progress so far - Data Loss + Cont Loss (Adam Optimizer)

Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop

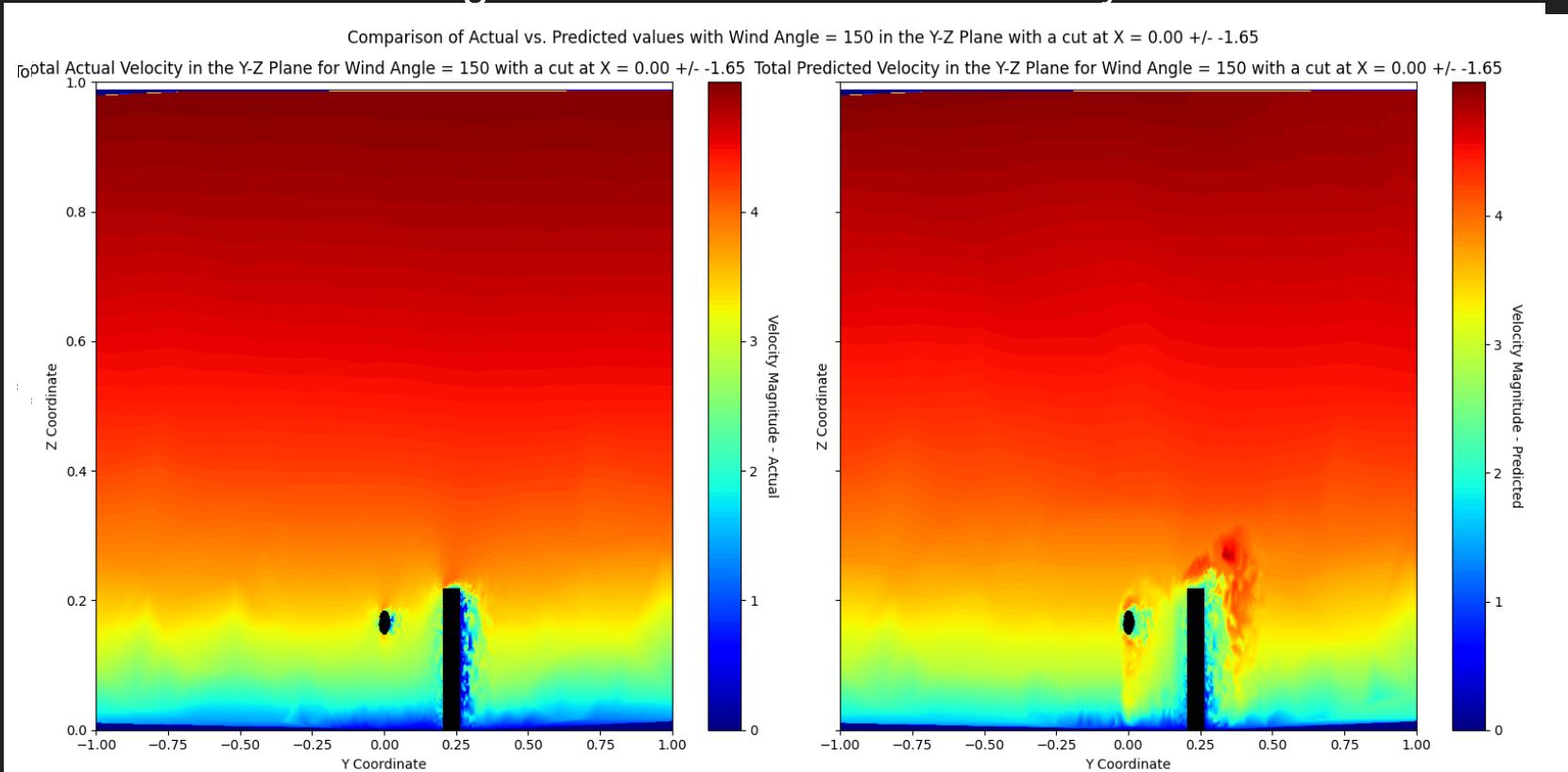
Testing Results – Y-Z Total Velocity Plot



Progress so far - Data Loss + Cont Loss (Adam Optimizer)

Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop

Testing Results – Y-Z Total Velocity Plot



Progress so far - Data Loss + Cont Loss (Adam Optimizer) Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop Testing Results – Y-Z Total Velocity Plot

Comparison of Actual vs. Predicted values with Wind Angle = 180 in the Y-Z Plane with a cut at X = 0.00 +/- -1.65

Actual Velocity in the Y-Z Plane for Wind Angle = 180 with a cut at X = 0.00 +/- -1.65

Predicted Velocity in the Y-Z Plane for Wind Angle = 180 with a cut at X = 0.00 +/- -1.65

Z Coordinate

Y Coordinate

Velocity Magnitude - Actual

Velocity Magnitude - Predicted

X Coordinate

Progress so far - Data Loss + Cont Loss (Adam Optimizer)

Threshold = 1E-5 (9120 Epochs, so far...),
GPU Laptop

Scripts v1 – PREDICTING (90,135 DEG)

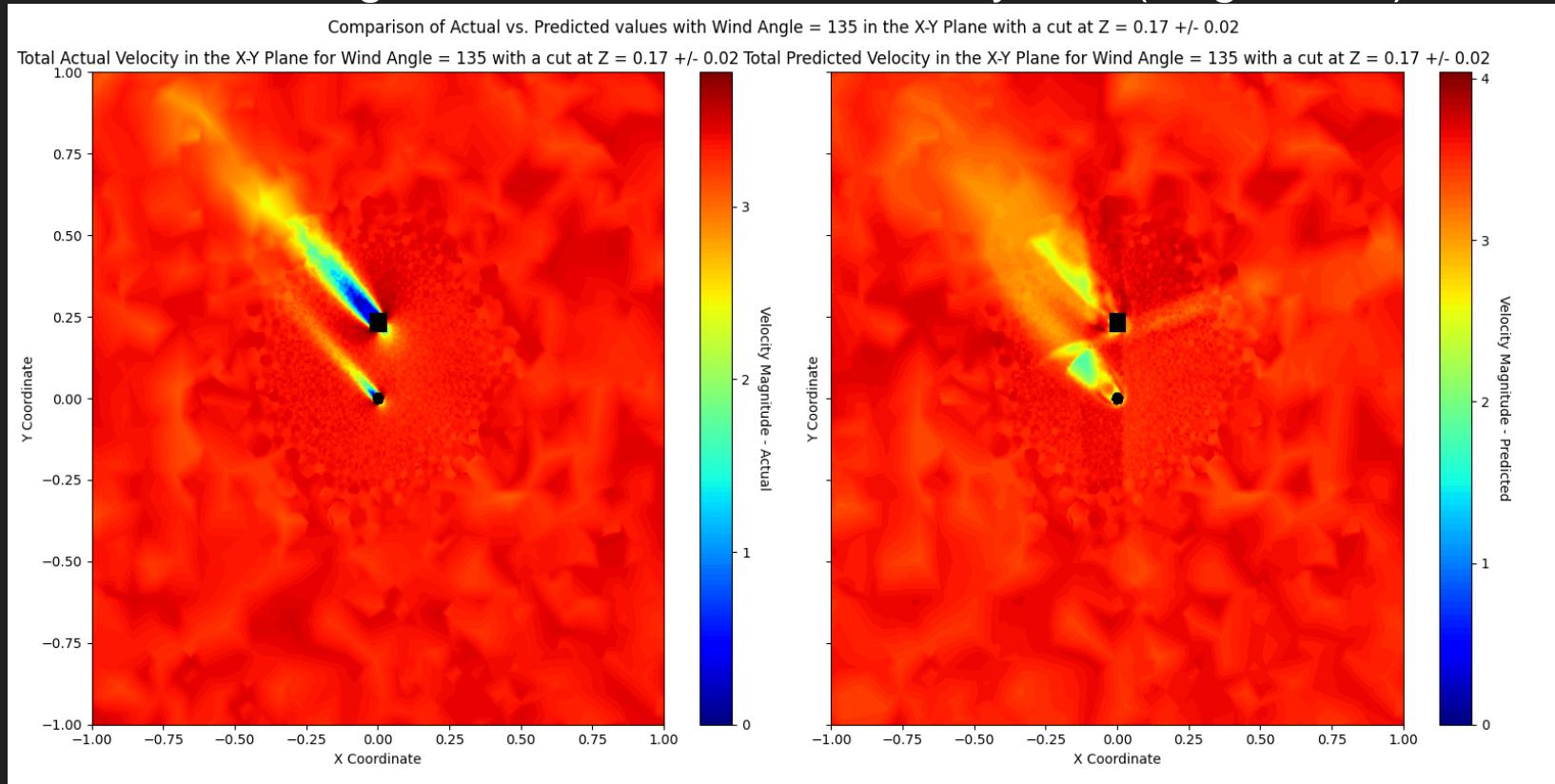
Progress so far - Data Loss + Cont Loss (Adam Optimizer)
Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop
Predicting Results – Metrics (Angle = 90)

Variable	MSE	RMSE	MAE	R2
Pressure	2.2540561	1.50135142	0.86987386	-0.2948265
Velocity:0	1.74568219	1.32124267	0.75204798	0.12026278
Velocity:1	4.33544267	2.08217258	1.99781828	-83.253256
Velocity:2	0.05317863	0.23060492	0.11664684	-0.6053989

Progress so far - Data Loss + Cont Loss (Adam Optimizer)

Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop

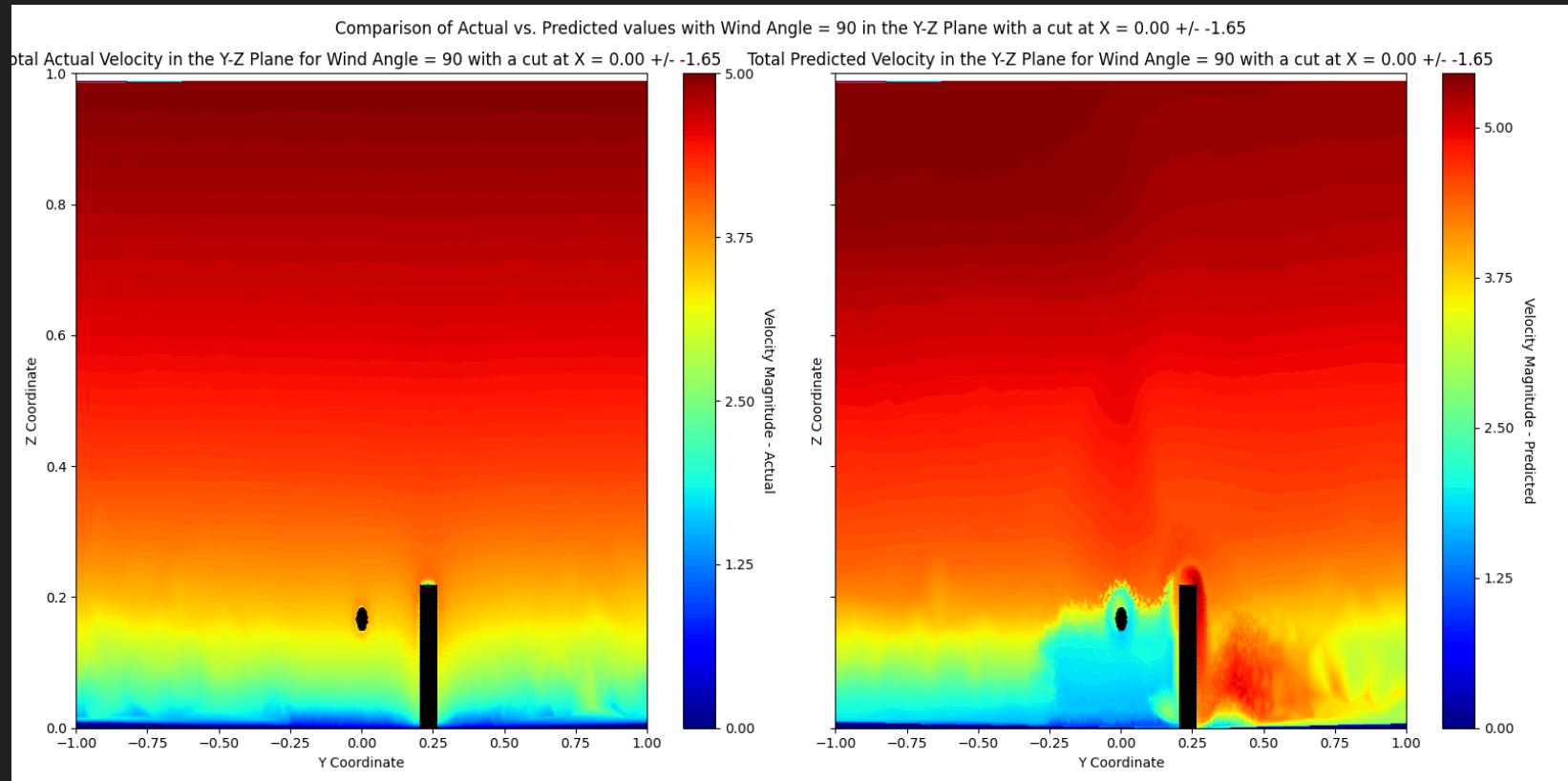
Predicting Results - X-Y Total Velocity Plot (Angle = 90)



Progress so far - Data Loss + Cont Loss (Adam Optimizer)

Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop

Predicting Results - Y-Z Total Velocity Plot (Angle = 90)



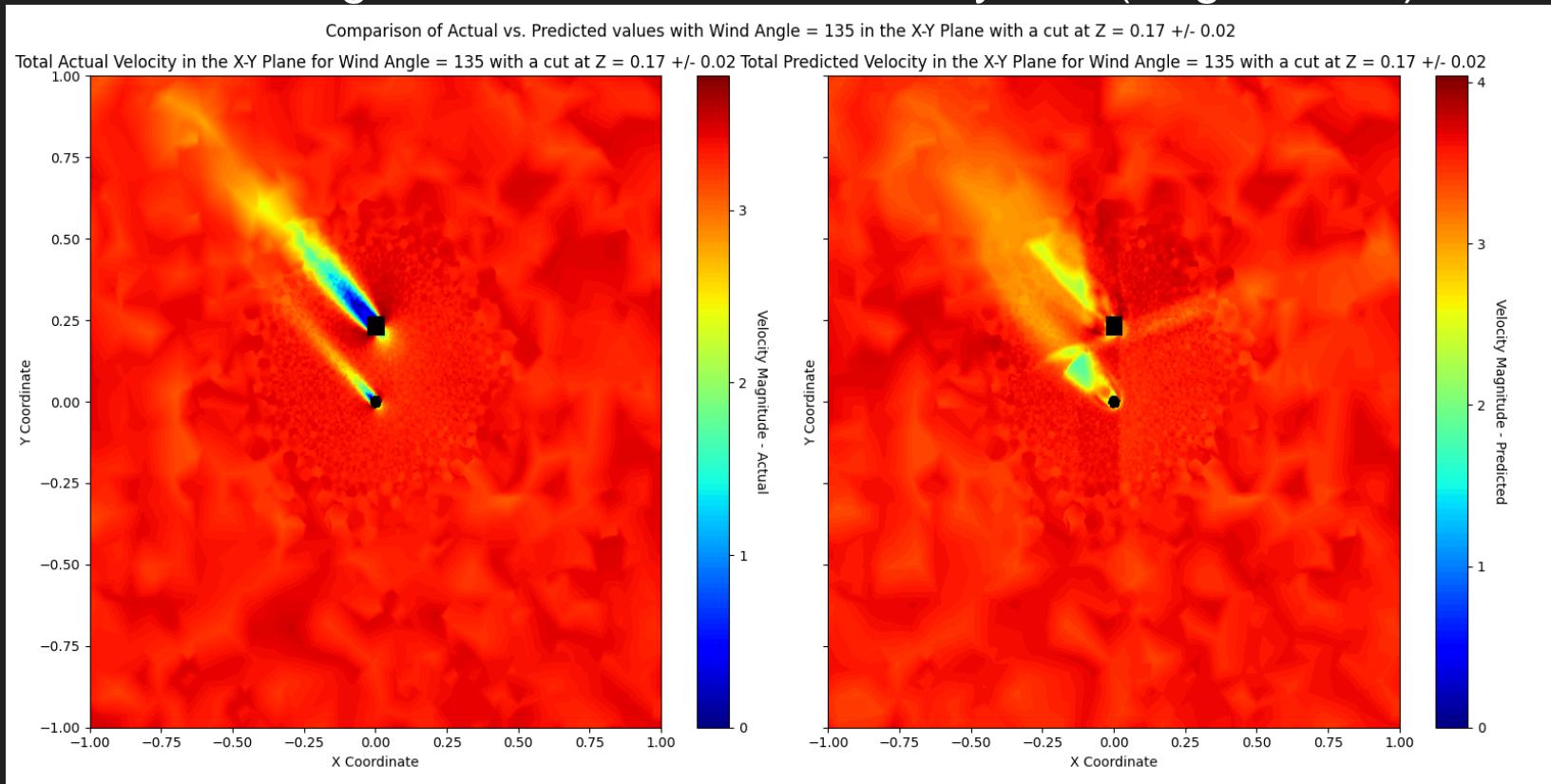
Progress so far - Data Loss + Cont Loss (Adam Optimizer)
Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop
Predicting Results – Metrics (Angle = 135)

Variable	MSE	RMSE	MAE	R2
Pressure	1.48405698	1.21821877	0.68451799	0.12204593
Velocity:0	0.29097088	0.53941716	0.24768495	0.71451734
Velocity:1	0.37020207	0.60844233	0.46084663	0.64024342
Velocity:2	0.02470386	0.15717463	0.06013675	0.2448527

Progress so far - Data Loss + Cont Loss (Adam Optimizer)

Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop

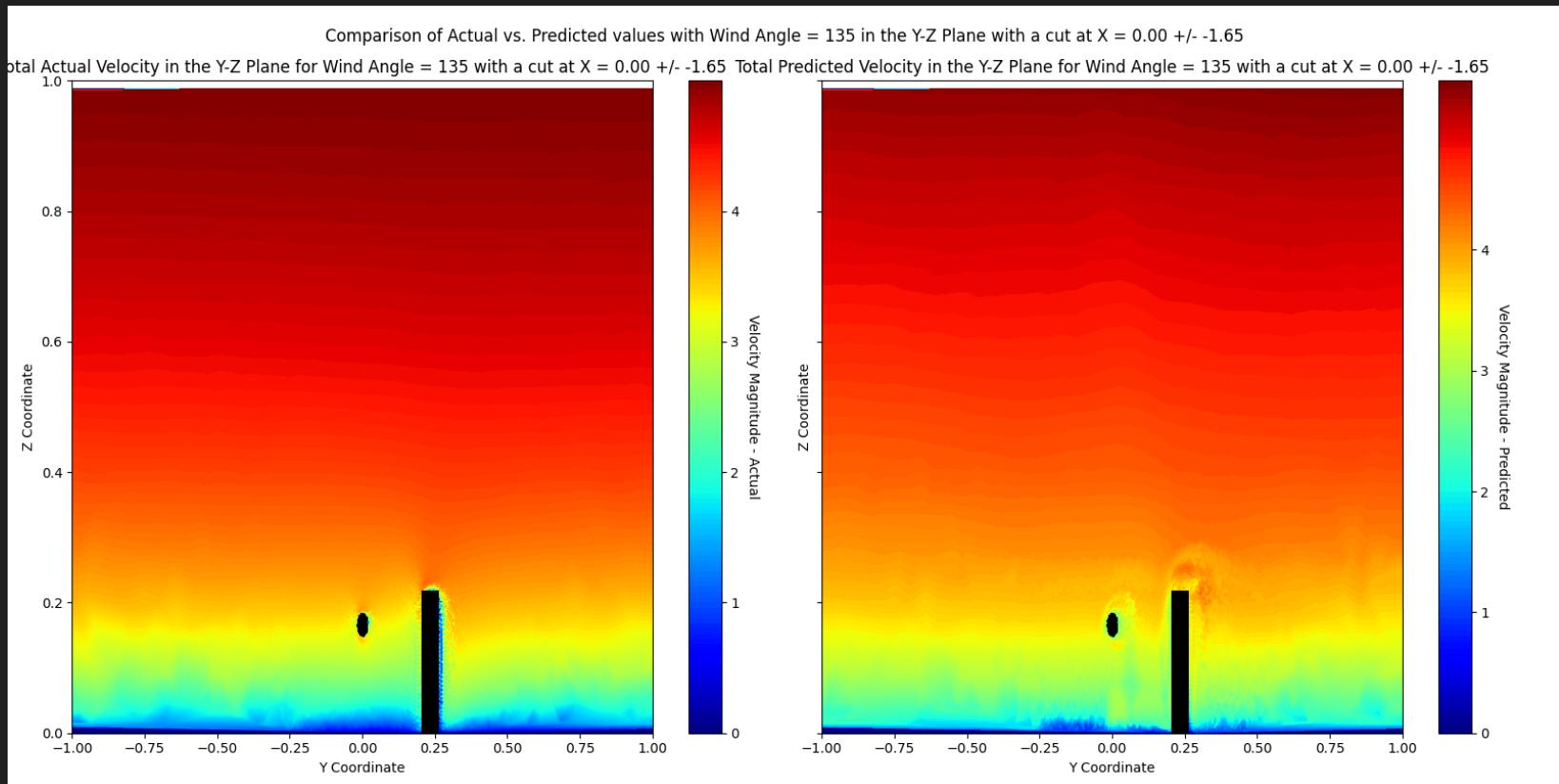
Predicting Results - X-Y Total Velocity Plot (Angle = 135)



Progress so far - Data Loss + Cont Loss (Adam Optimizer)

Threshold = 1E-5 (9120 Epochs, so far...), GPU Laptop

Predicting Results - Y-Z Total Velocity Plot (Angle = 135)



Progress so far - Data Loss + Cont Loss +
RANS Loss (Adam Optimizer)

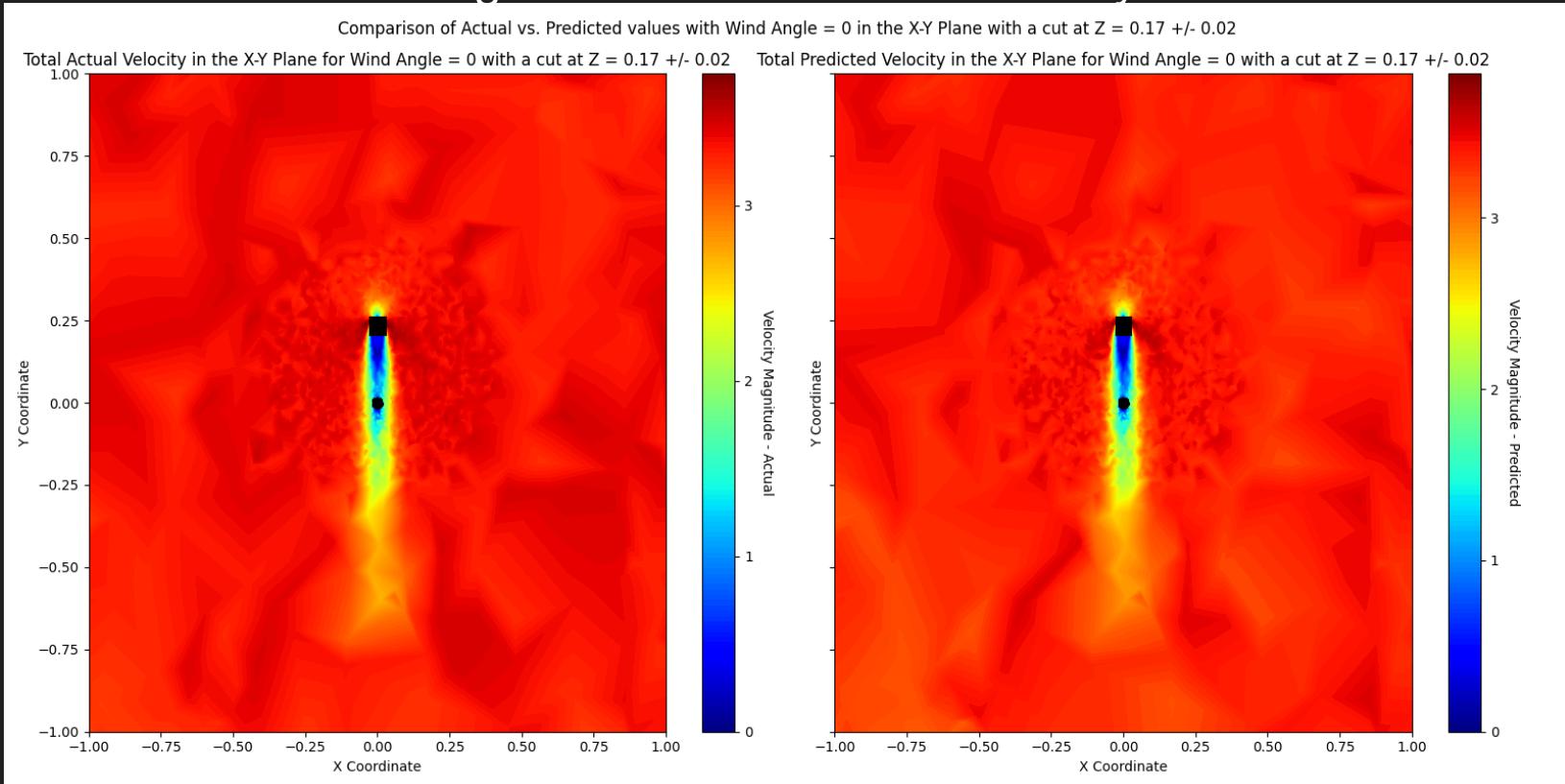
Threshold = 1E-5 (5400 Epochs, so far...),
GPU Workstation

Scripts v1 - TESTING

Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)
Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation
Testing Results - Metrics

Variable	MSE	RMSE	MAE	R2
Pressure	0.00364972	0.06041294	0.03737356	0.99922606
Velocity:0	0.00168196	0.04101172	0.02408311	0.99916676
Velocity:1	0.00385195	0.06206411	0.03741128	0.9995341
Velocity:2	0.00012084	0.01099263	0.00596333	0.99609346

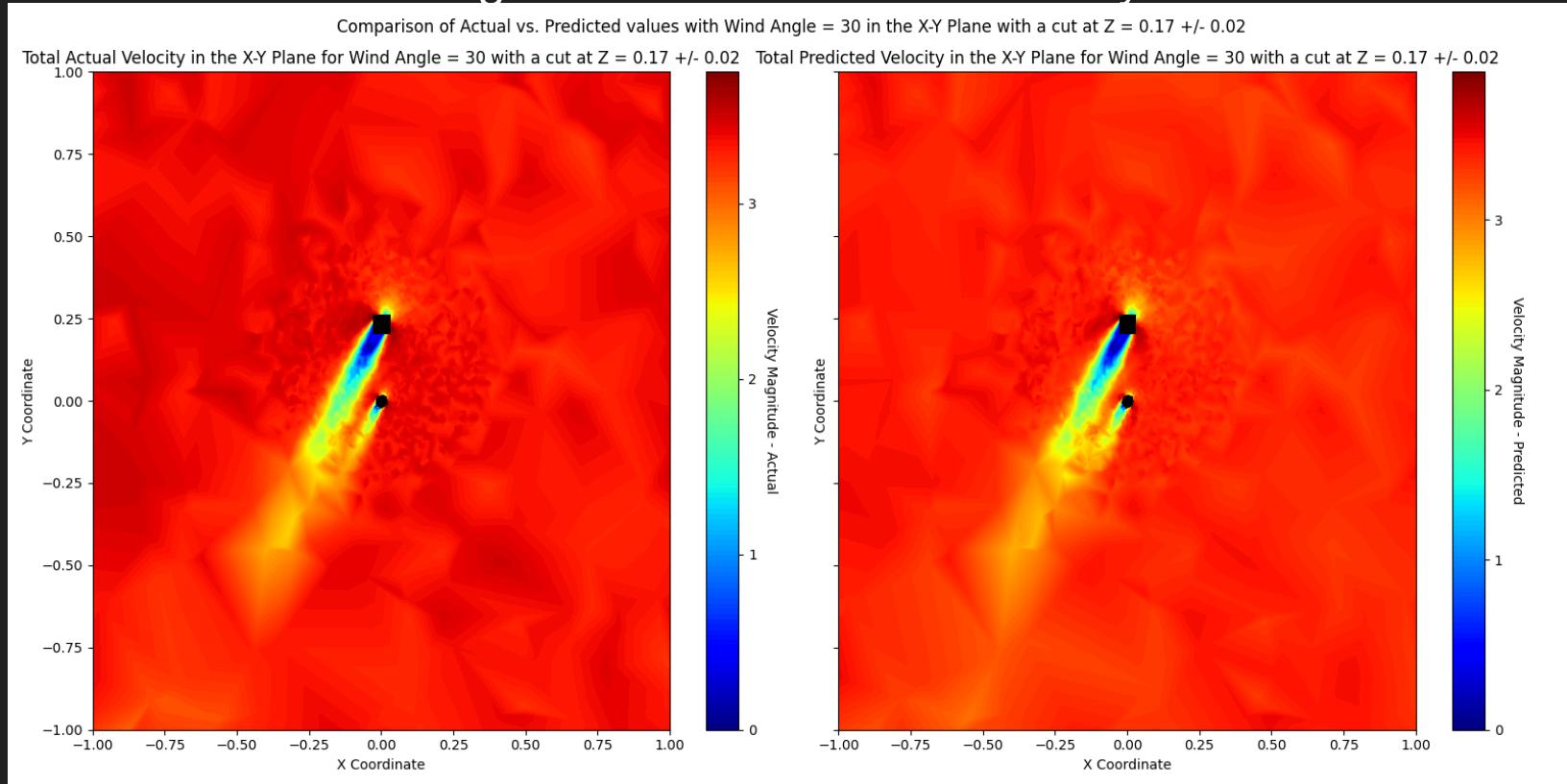
Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)
Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation
Testing Results - X-Y Total Velocity Plot



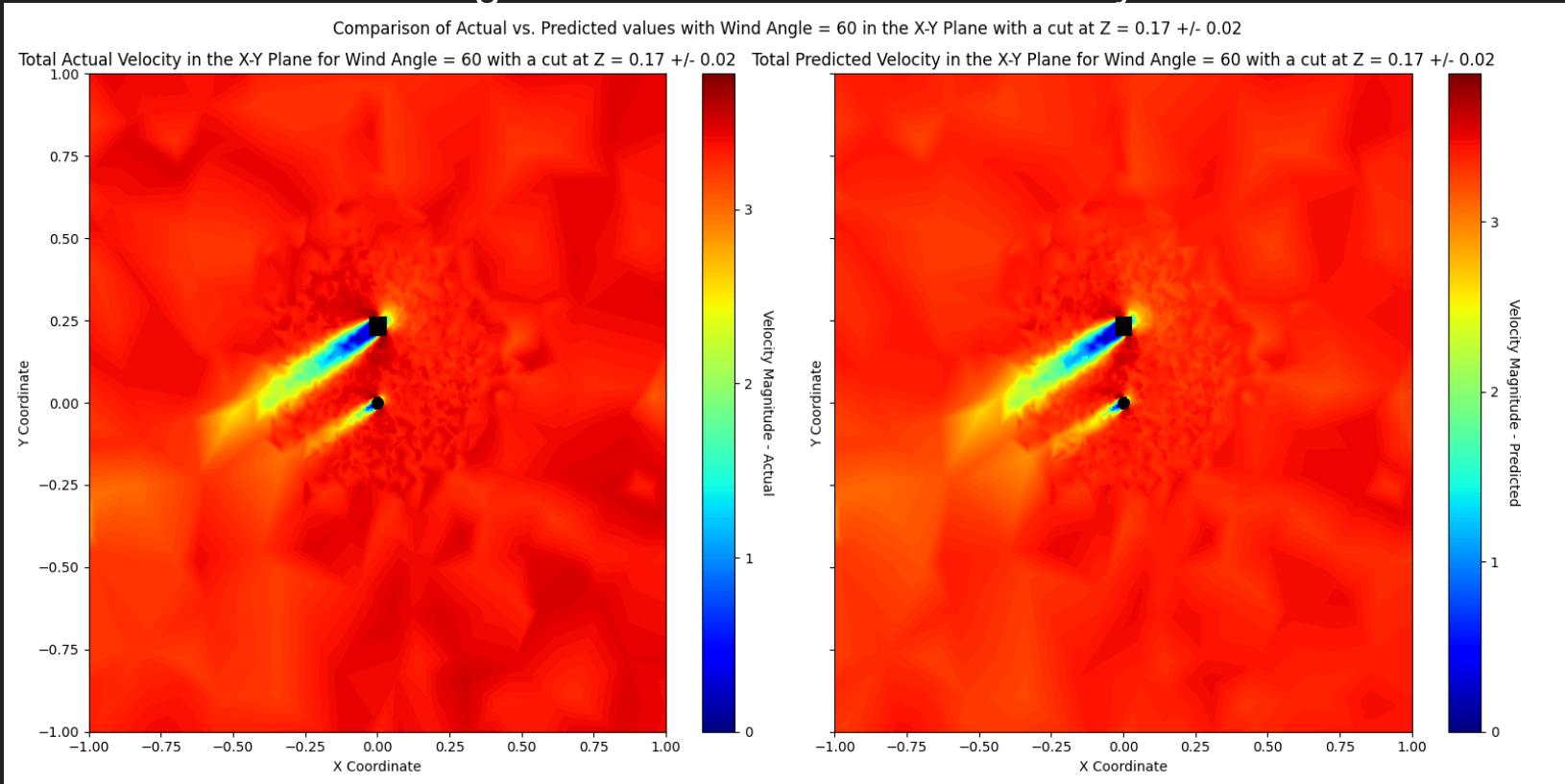
Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)

Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation

Testing Results - X-Y Total Velocity Plot



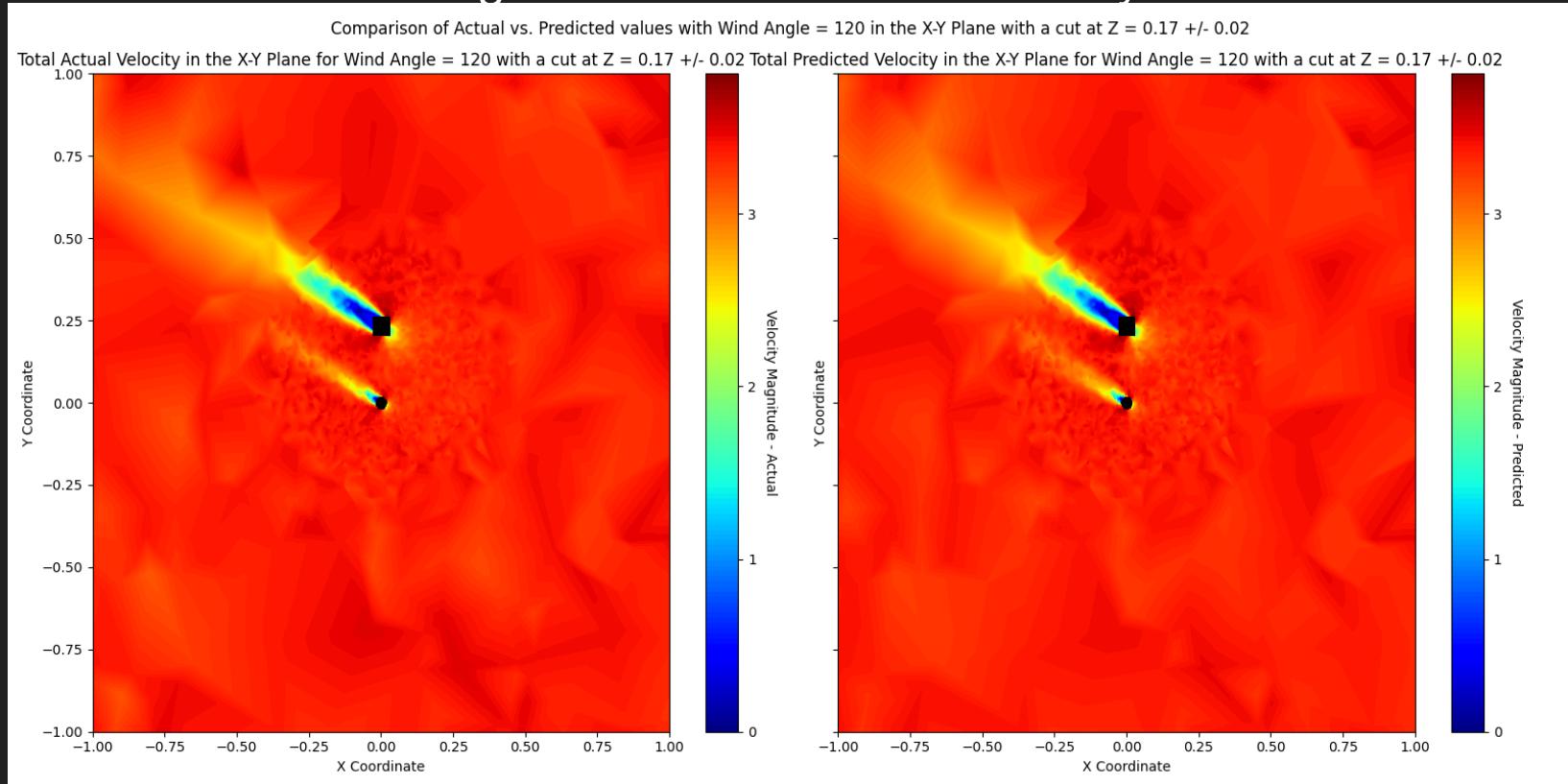
Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)
Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation
Testing Results - X-Y Total Velocity Plot



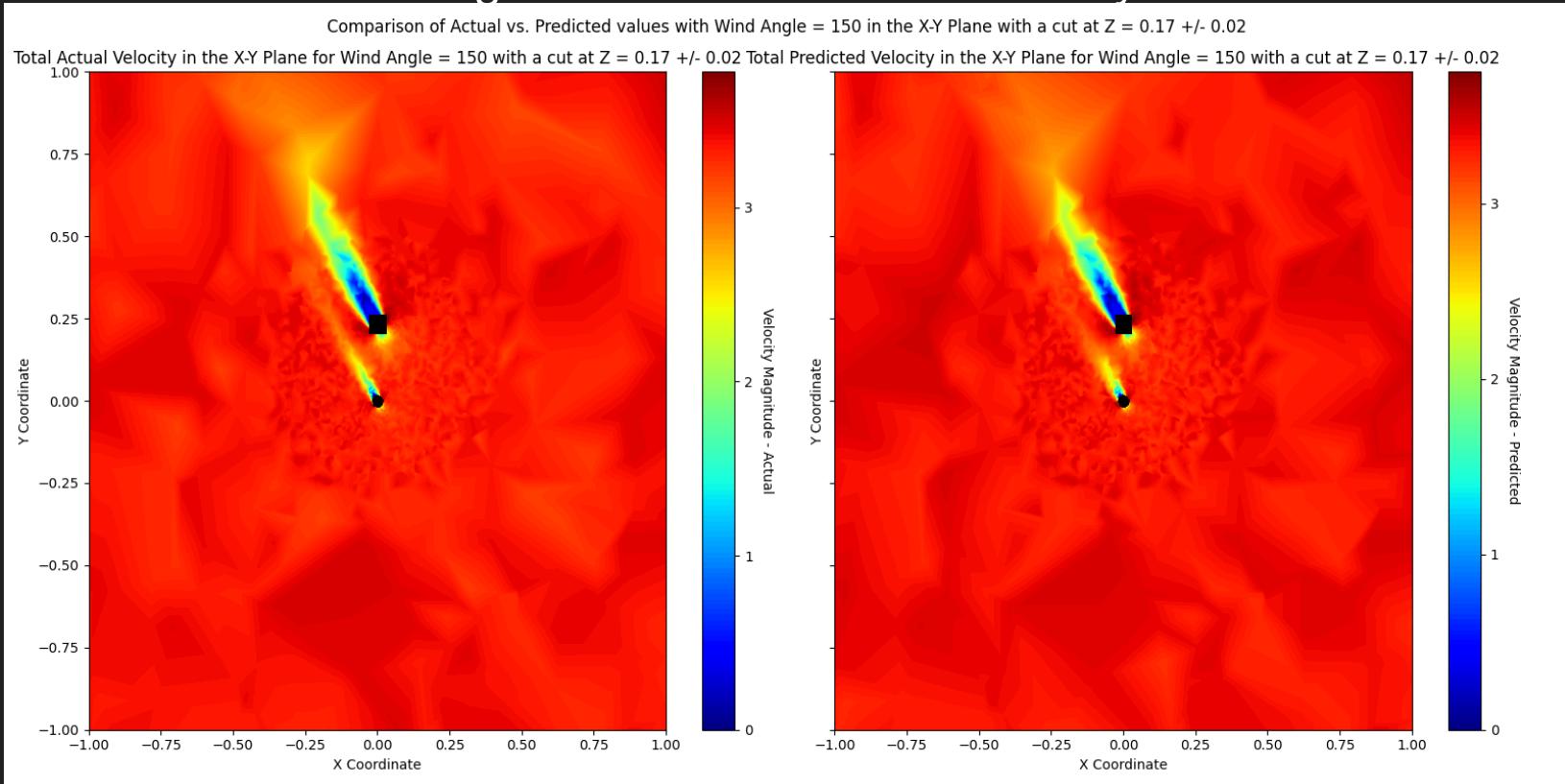
Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)

Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation

Testing Results - X-Y Total Velocity Plot



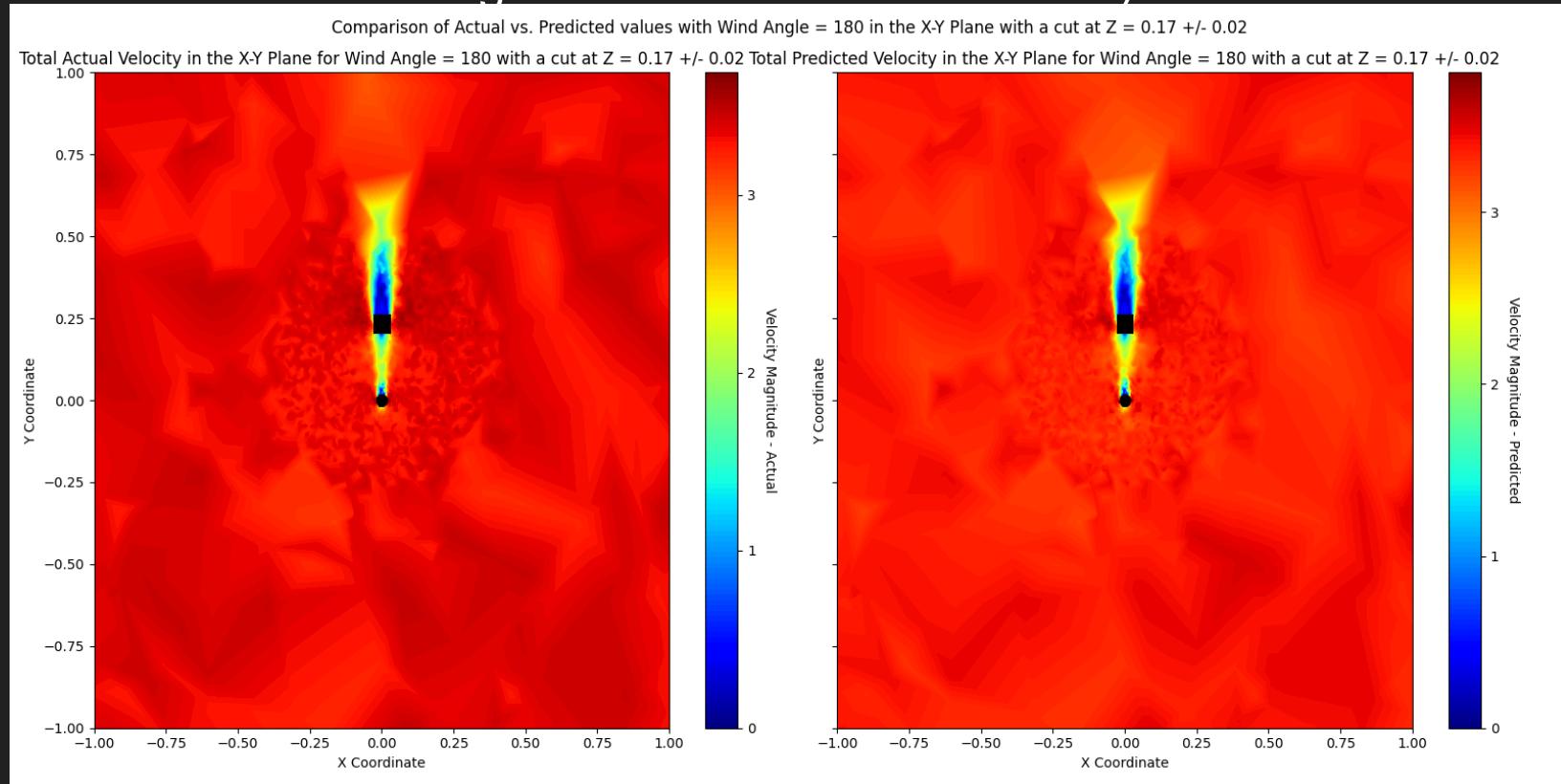
Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)
Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation
Testing Results - X-Y Total Velocity Plot



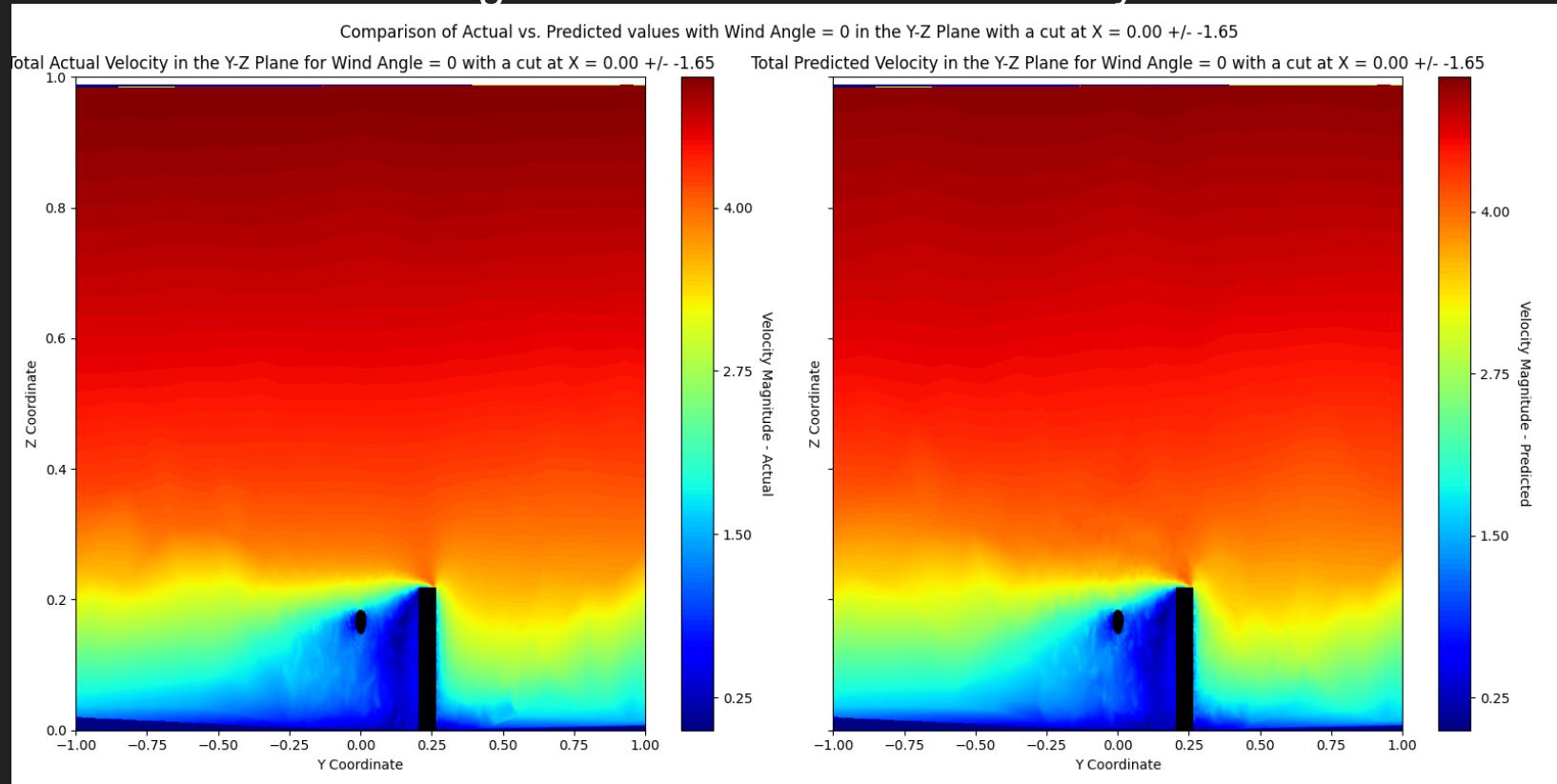
Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)

Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation

Testing Results - X-Y Total Velocity Plot



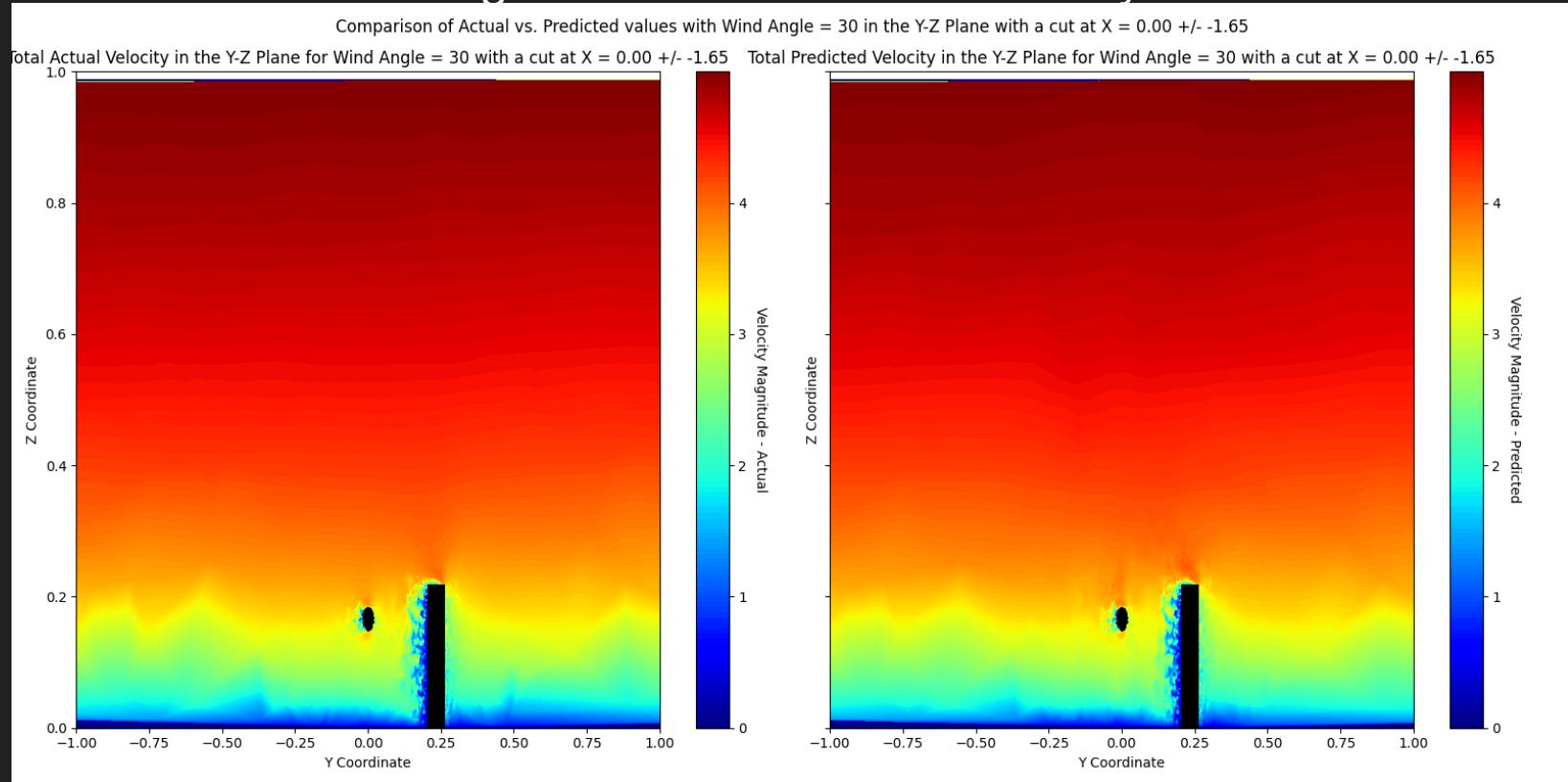
Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)
Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation
Testing Results - X-Y Total Velocity Plot



Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)

Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation

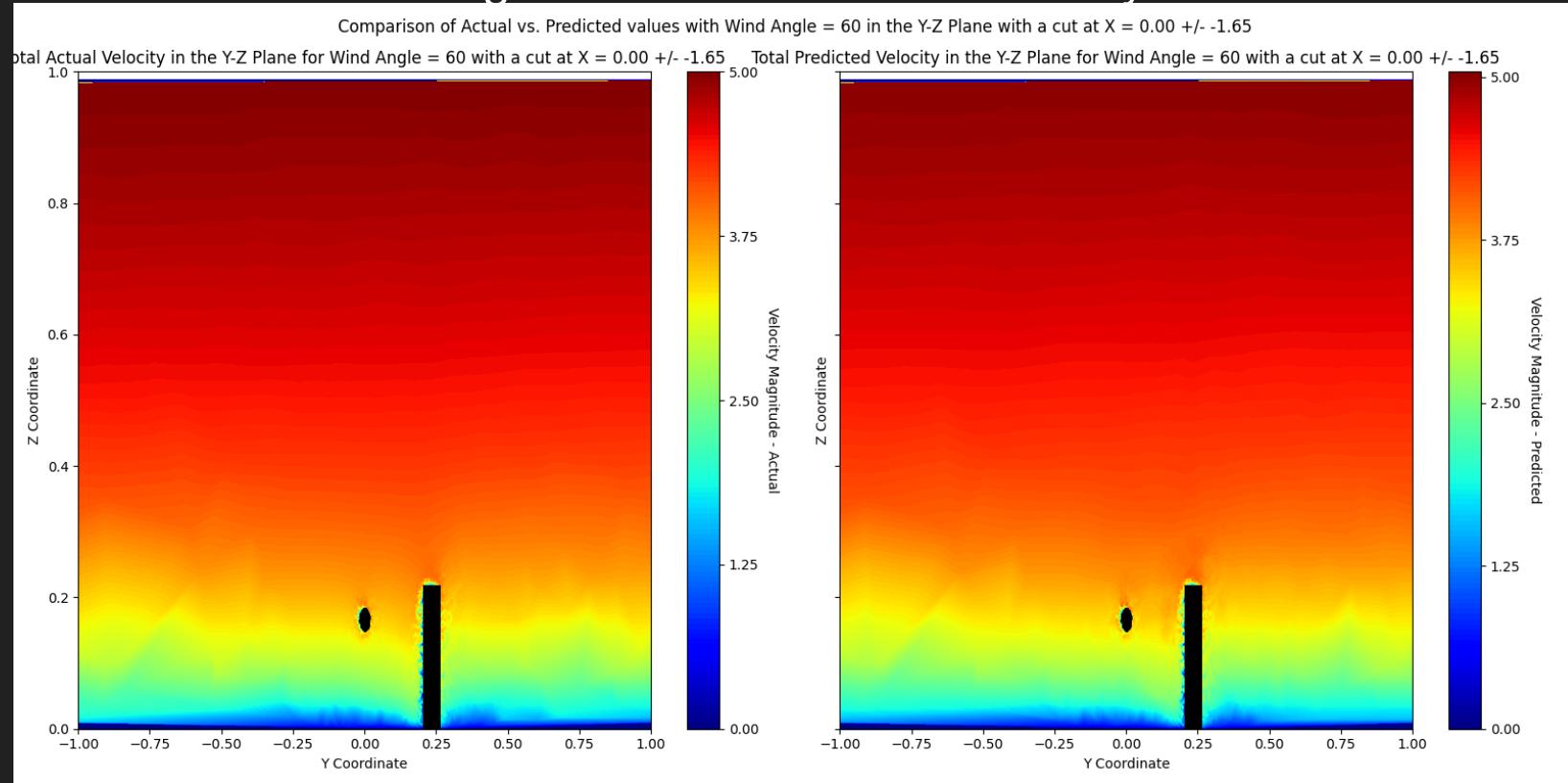
Testing Results - X-Y Total Velocity Plot



Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)

Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation

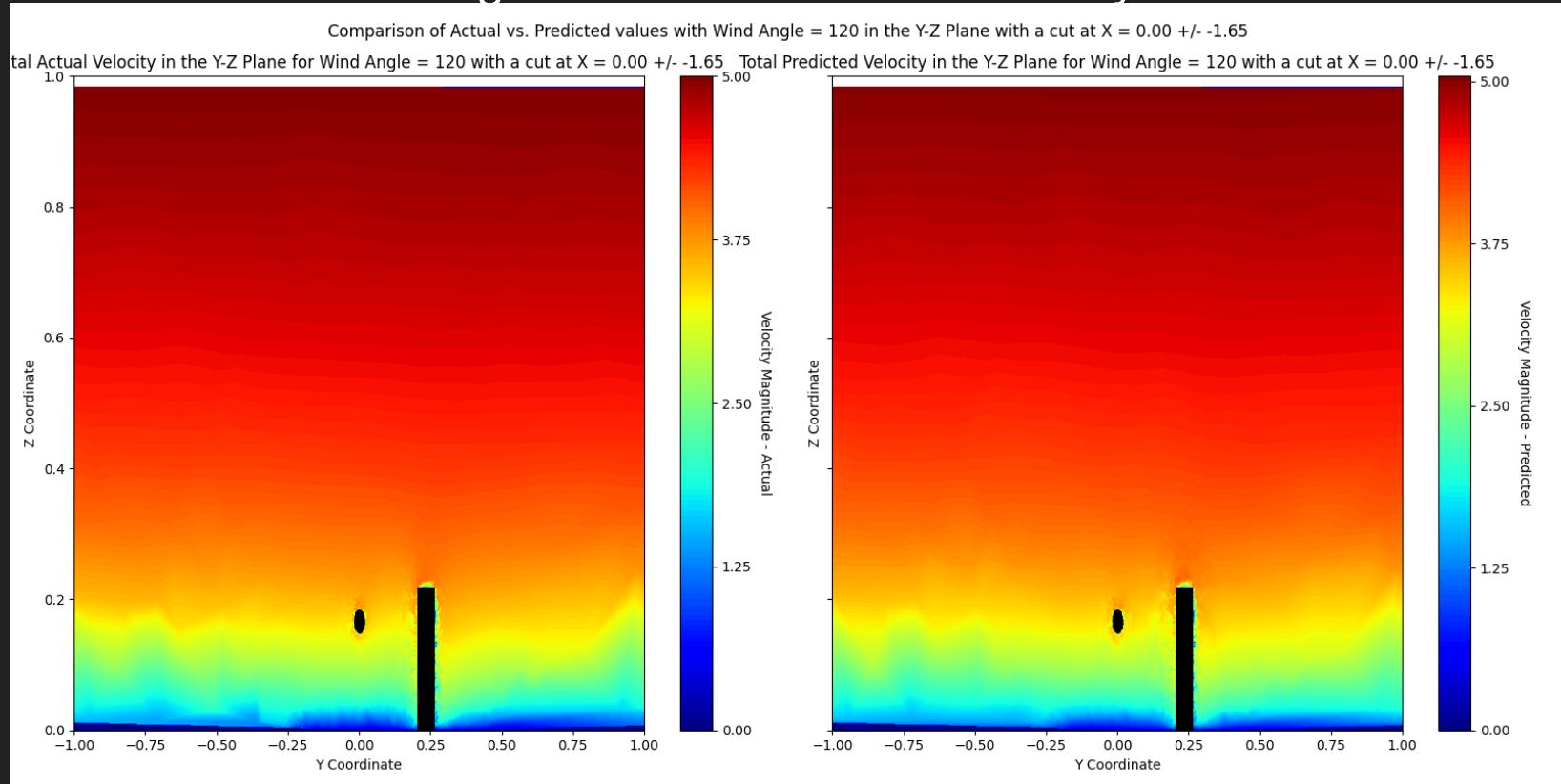
Testing Results - X-Y Total Velocity Plot



Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)

Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation

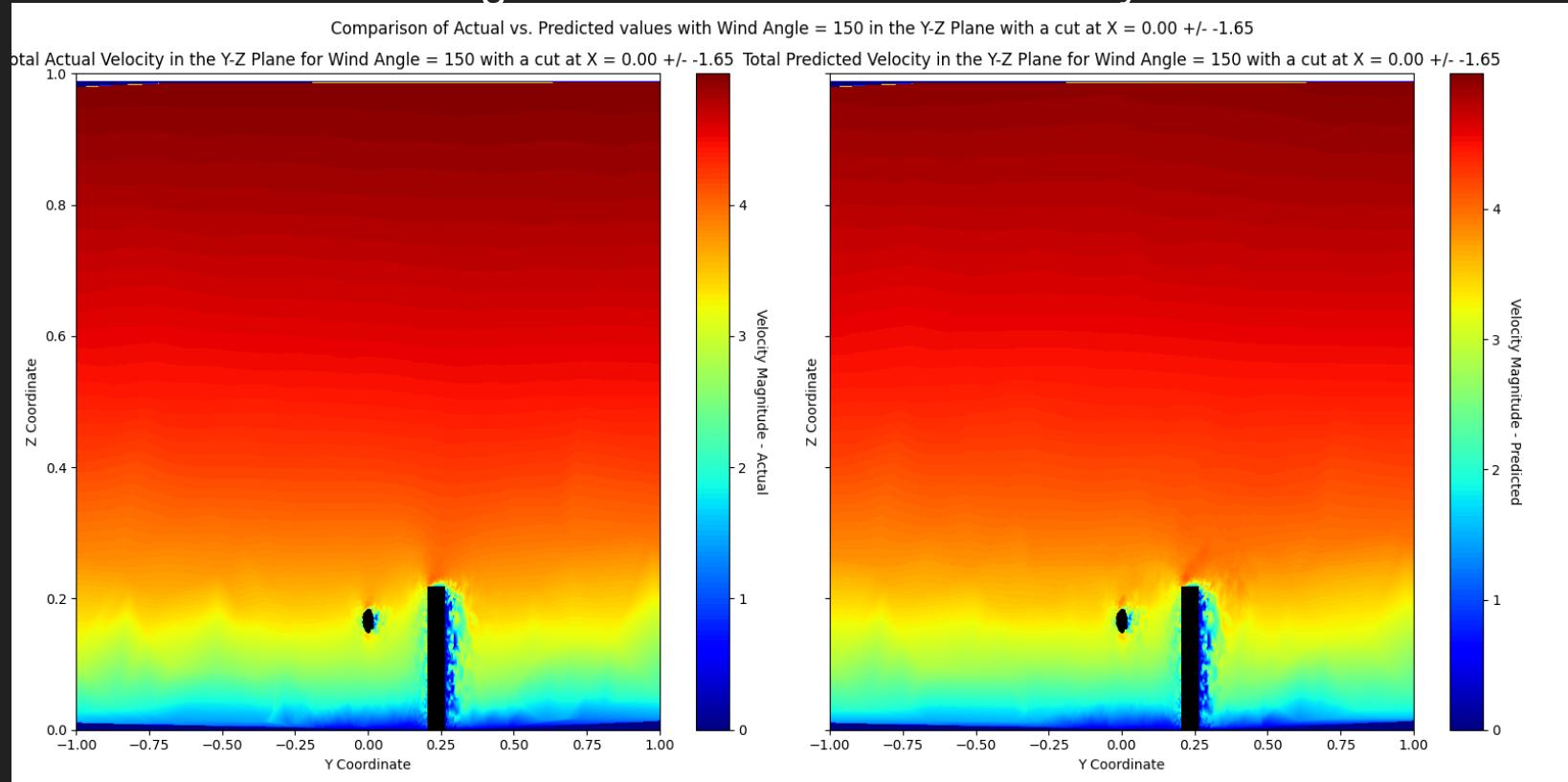
Testing Results - X-Y Total Velocity Plot



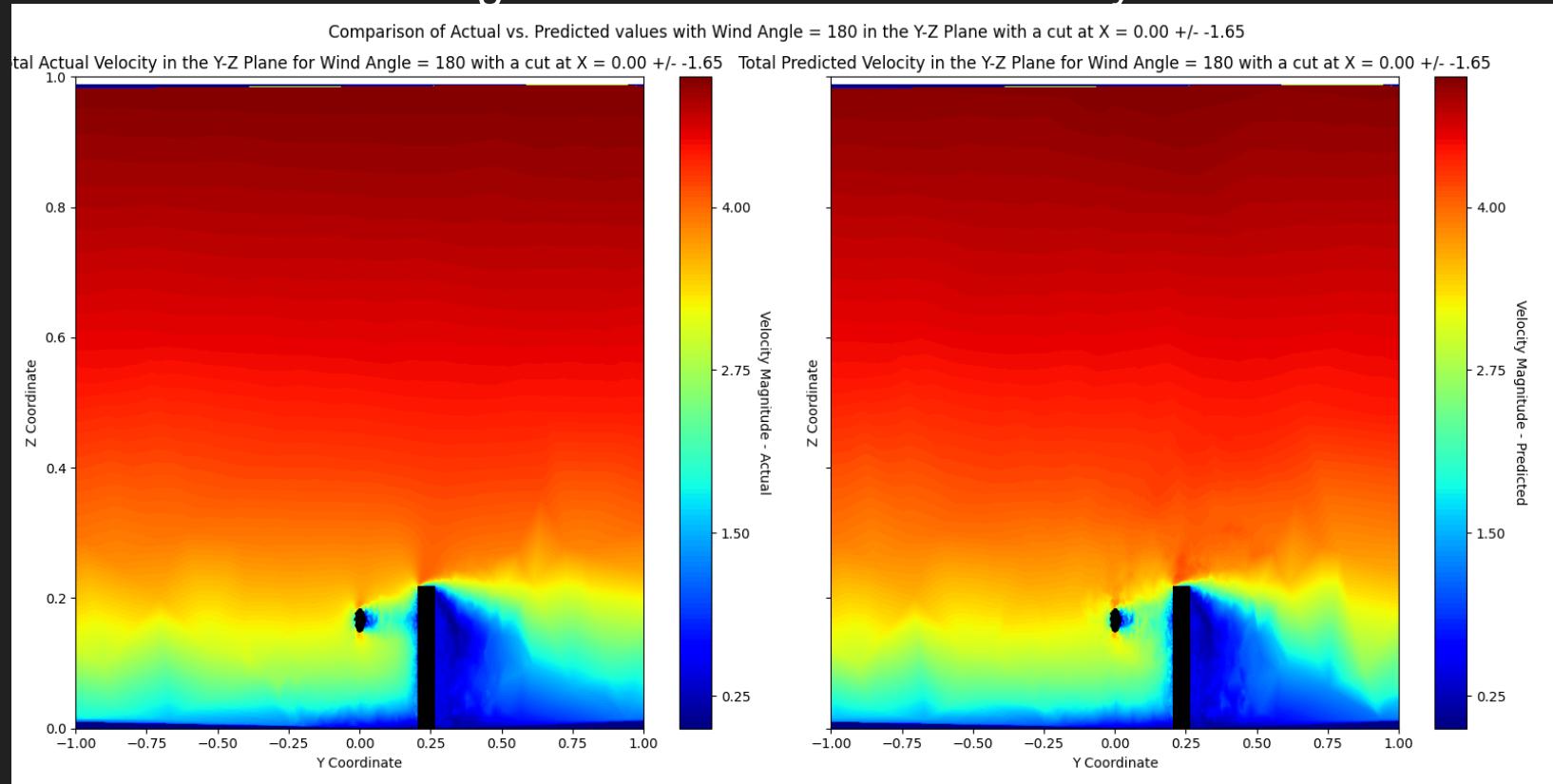
Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)

Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation

Testing Results - X-Y Total Velocity Plot



Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)
Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation
Testing Results - X-Y Total Velocity Plot



Progress so far - Data Loss + Cont Loss +
RANS Loss (Adam Optimizer)

Threshold = 1E-5 (5400 Epochs, so far...),
GPU Workstation

Scripts v1 – PREDICTING (90,135 DEG)

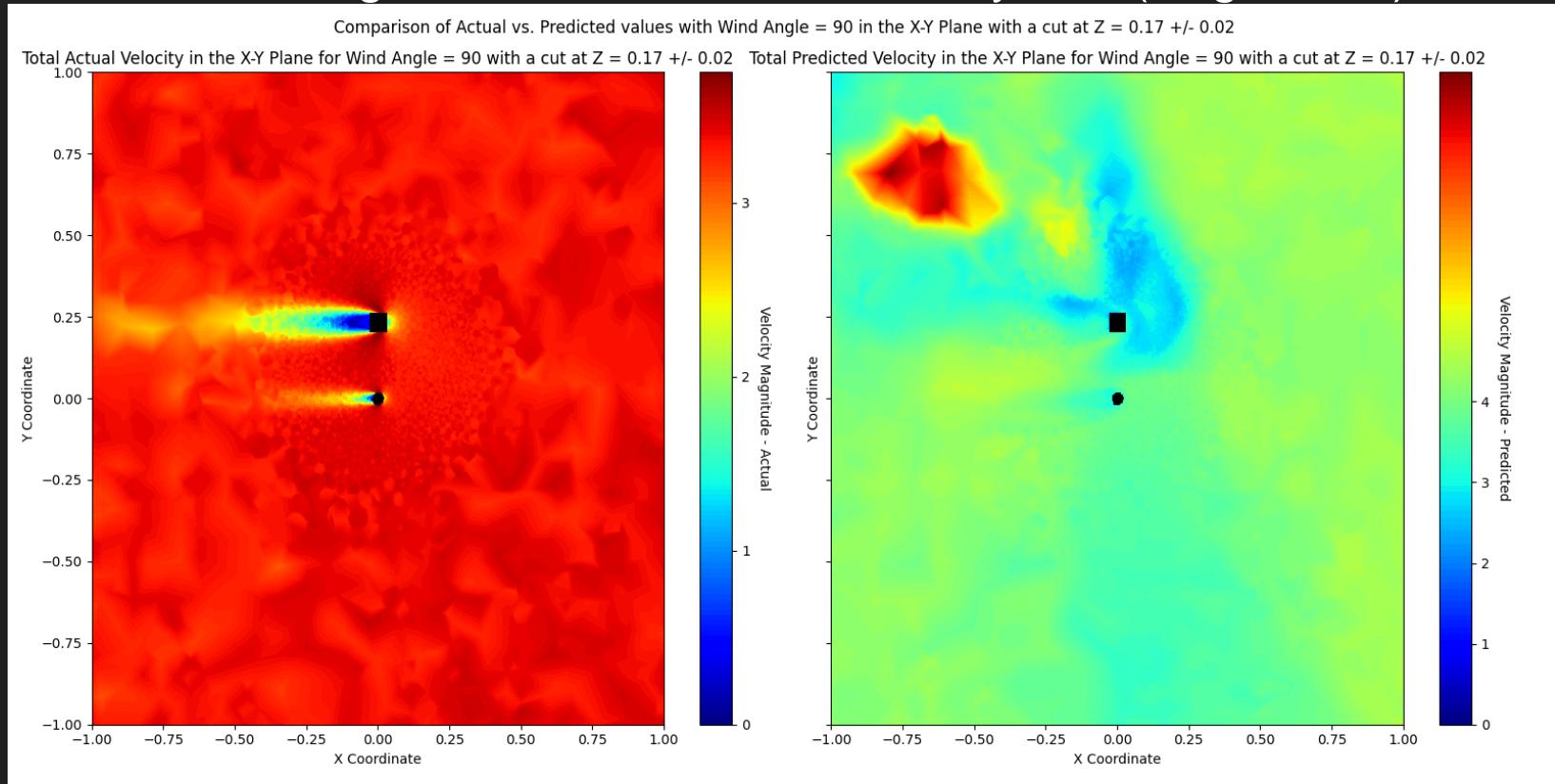
Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)
Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation
Predicting Results – Metrics (Angle = 90)

Variable	MSE	RMSE	MAE	R2
Pressure	29.8978071	5.46788872	3.85787731	-16.174583
Velocity:0	1.02771039	1.01376052	0.90530051	0.48208495
Velocity:1	0.61835036	0.78635257	0.5696696	-11.016773
Velocity:2	0.7911997	0.88949407	0.45162508	-22.885368

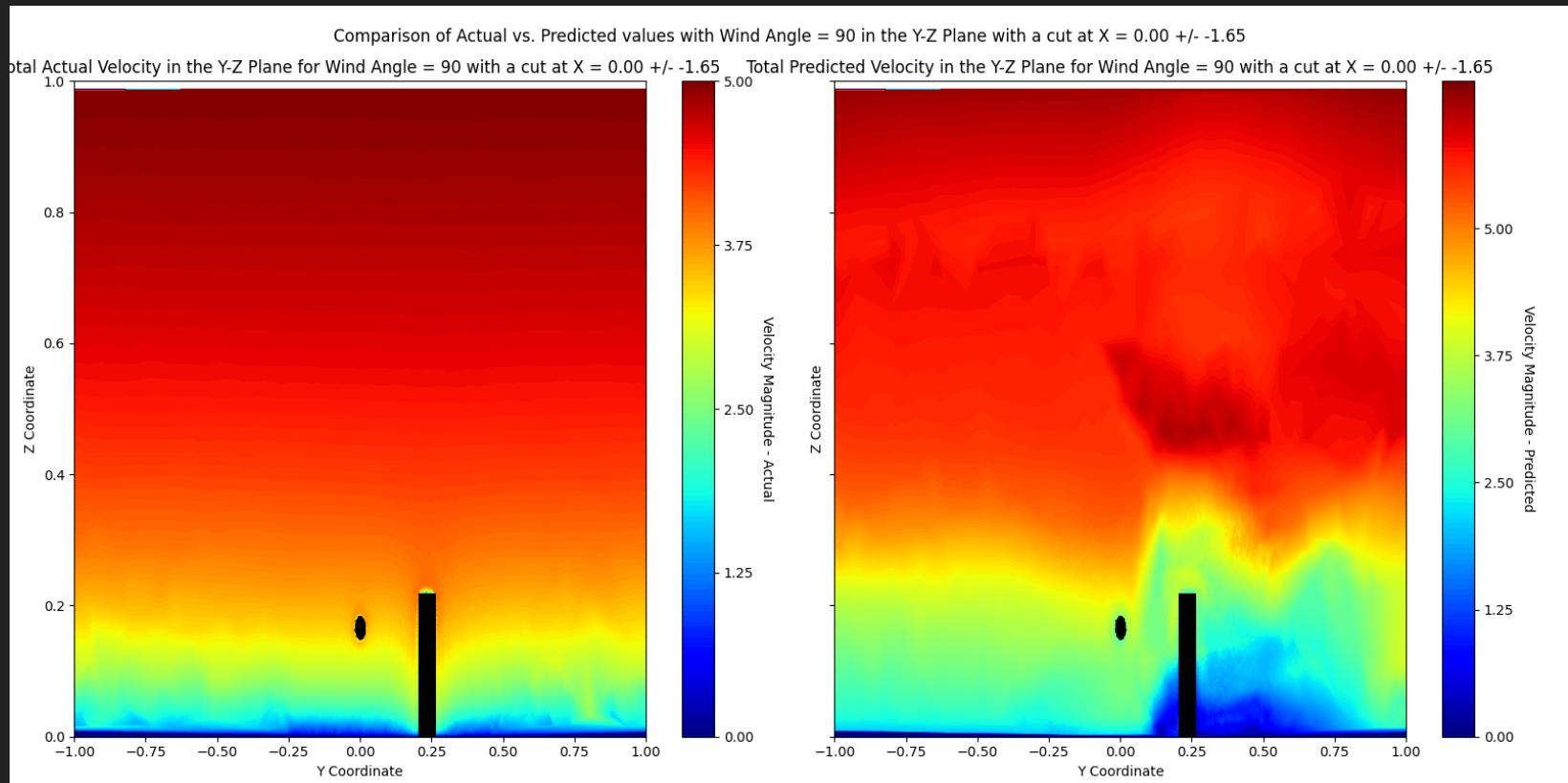
Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)

Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation

Predicting Results - X-Y Total Velocity Plot (Angle = 90)



Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)
Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation
Predicting Results - Y-Z Total Velocity Plot (Angle = 90)



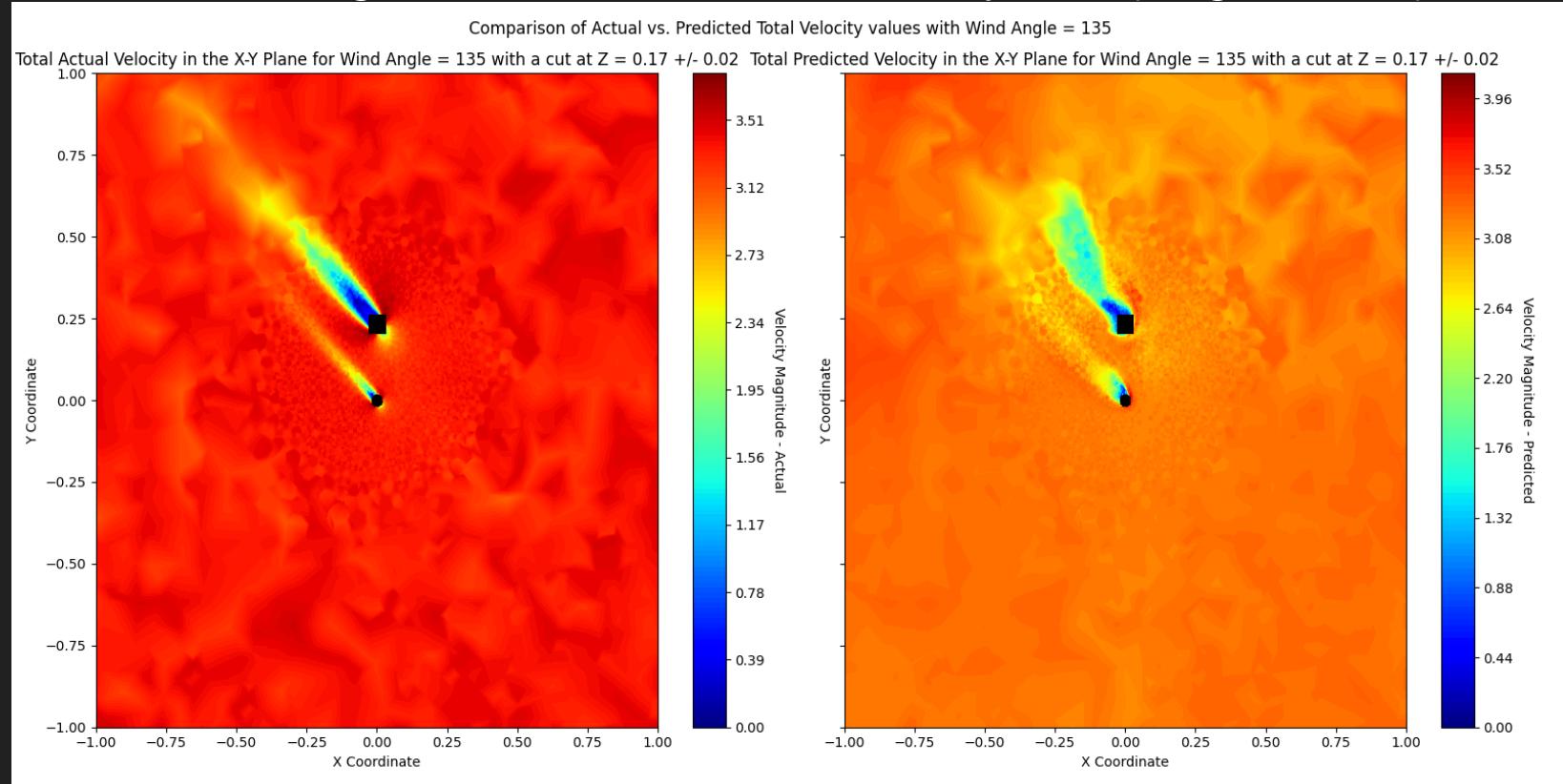
Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)
Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation
Predicting Results – Metrics (Angle = 135)

Variable	MSE	RMSE	MAE	R2
Pressure	1.55444569	1.24677411	0.58380363	0.08040464
Velocity:0	0.28687284	0.53560512	0.38439829	0.71853807
Velocity:1	0.2985522	0.5463993	0.3817838	0.70987164
Velocity:2	0.02667502	0.16332491	0.06180706	0.1845983

Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)

Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation

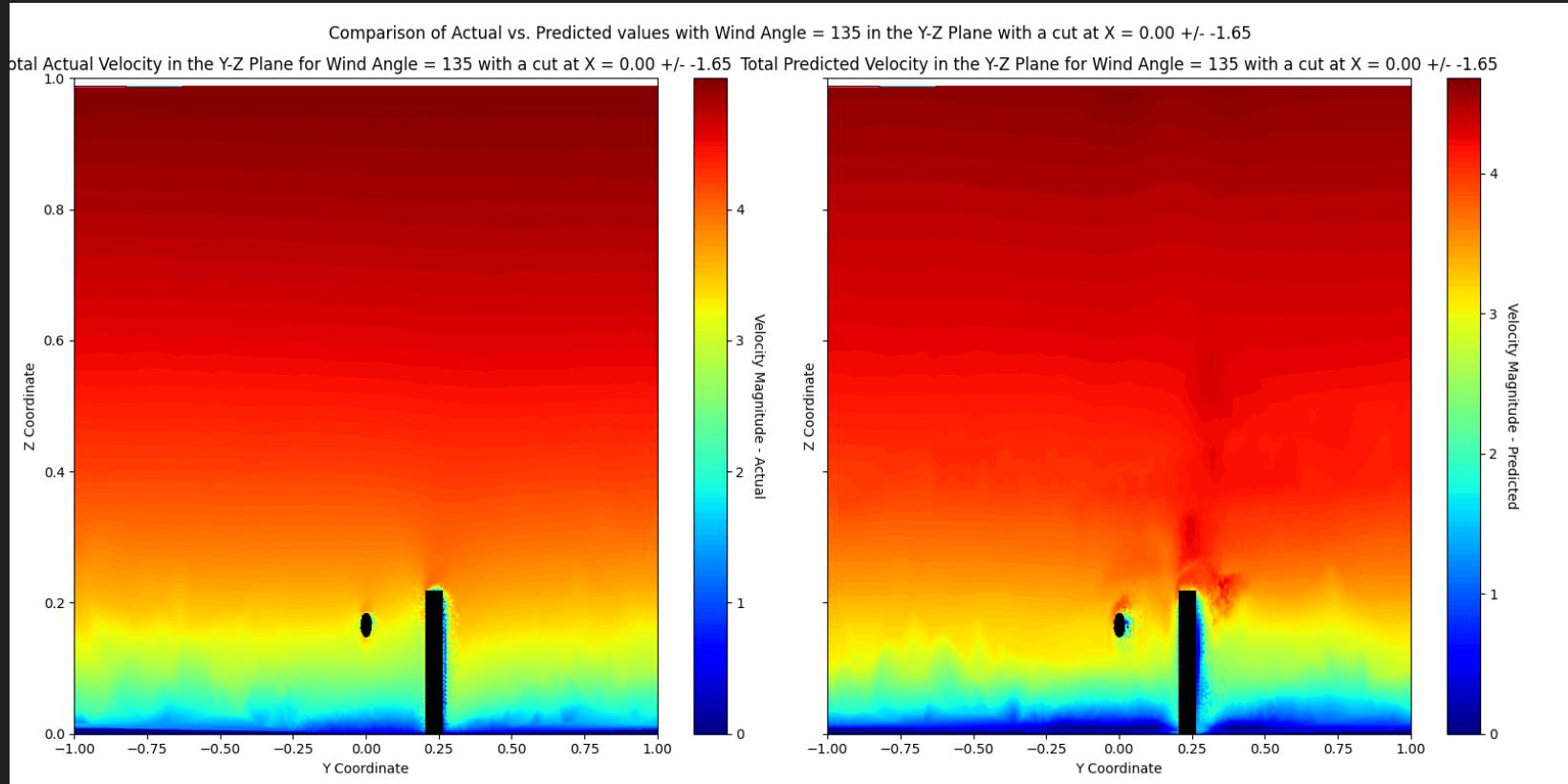
Predicting Results - X-Y Total Velocity Plot (Angle = 135)



Progress so far - Data Loss + Cont Loss + RANS Loss (Adam Optimizer)

Threshold = 1E-5 (5400 Epochs, so far...), GPU Workstation

Predicting Results - Y-Z Total Velocity Plot (Angle = 135)



Scripts v2 – Preliminary Results

Progress so far - Data Loss Only
Min-Max Scalar
(Adam Optimizer)

Threshold = 1E-5 (18850 Epochs,
completed), GPU Laptop

Scripts v2 – PREDICTING (135 DEG)

Some Parameters

Infinite epochs - instead the criteria for stopping is $\text{loss}_{\{n\}} - \text{loss}_{\{n-1\}} < \epsilon$ for 10 consecutive epochs where n is the epoch number and $\epsilon = 1E-5$ (user defined)

We have the data for 8 angles, [0, 30, 60, 90, 120, 135, 150, 180] in degrees

We concatenate the data for angles = [0, 30, 60, 90, 120, 150, 180] and then take 99.99% of the dataset with random seed = 42 for training and 0.01% for testing

By using the whole dataset we hope to make the NN learn about wind angle such that the parameters become functions of the wind angle

Then using the trained neural network we predict the data for angle = 135

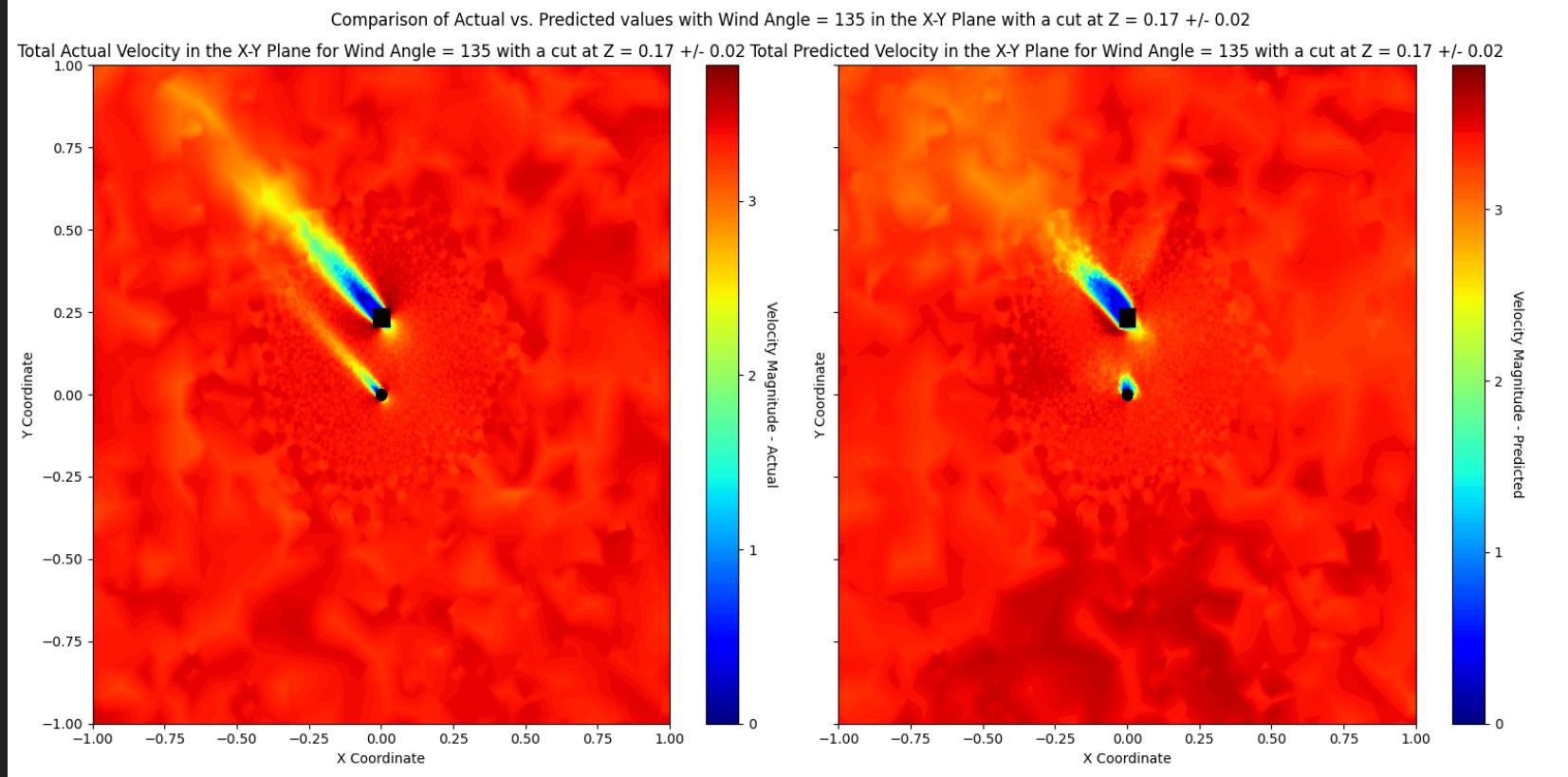
Progress so far - Data Loss Only (Adam Optimizer – Min-Max Scalar)
Threshold = 1E-5 (18390 Epochs, so far...), GPU Laptop
Predicting Results – Metrics (Angle = 135)

Variable	MSE	RMSE	MAE	R2
Pressure	1.0398	1.0197	0.4333	0.3849
Velocity:0	0.1004	0.3167	0.1803	0.9014
Velocity:1	0.09228	0.3038	0.1902	0.9103
Velocity:2	0.03527	0.1878	0.0754	-0.0782
TurbVisc	0.30358	0.5510	0.4022	0.9978

Progress so far - Data Loss Only (Adam Optimizer – Min-Max Scalar)

Threshold = 1E-5 (18390 Epochs, so far...), GPU Laptop

Predicting Results - X-Y Total Velocity Plot (Angle = 135)



Progress so far - Data Loss Only (Adam Optimizer – Min-Max Scalar)

Threshold = 1E-5 (18390 Epochs, so far...), GPU Laptop

Predicting Results - Y-Z Total Velocity Plot (Angle = 135)

